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Editorial

This first edition of the REAAA Journal for 2004 contains three papers. The first paper "New Zealand's Performance Specifications for Design and Construction of Unbound Granular Pavements", was prepared by Bryan Pidwerbesky, Fulton Hogan Ltd, and David Alabaster, University of Canterbury, New Zealand. This paper won the REAAA New Zealand Chapter's best Technical Paper Award for 2003 for 'the practical application of research'. The competition is again being run in 2004 and details are contained in this issue.

The second paper, "Willingness of Drivers to Pay for Transport Information in Malaysia", by Chow Yih Woei and Ravi Shankar of IKRAM College, Malaysia, and Dadang Mohamad Ma'soem, from the Universiti Putra, Malaysia, describes a study which involved the evaluation of various Integrated Transport Information Systems and the willingness of both private vehicle users and public transport users to pay for this information. This paper is the first to be refereed in line with the procedures outlined in the 2003 issue of the Journal.

The third paper was prepared by David Anderson, the CEO of Victoria's State Road Authority, VicRoads. The paper presents details of the operation of VicRoads and the steps that it has taken to provide convenient and cost-effective services to its customers.

The Hanyang University Accelerated Pavement Tester (HAPT) is the first full-scale accelerated pavement tester developed in Korea and it has already been successfully used in various research projects. Details of the device are presented in a short article prepared by Young Chan Suh, Hanyang University, and Hee Mun Park of the Korea Institute of Construction Technology.

A new addition to the Journal this year is details of forthcoming Conference, both inside and outside the region, which may be of interest to readers. In all cases, contact details (including generally a Webpage address) are provided to allow readers to seek further information if they so desire. One Conference highlighted in this issue is the 6th International Conference on Managing Pavements, which will be held from 19-24 October 2004 at the Brisbane Convention & Exhibition Centre, Brisbane, Australia. The International Pavement Management Conferences held over the last ten years have recognised in their themes the importance of institutional issues and sustainability, as well as the importance of innovation in technical capabilities and practices. A series of pre-Conference Workshops and an "investment challenge" are to be held as part of the program. Readers are referred both to the article in this issue of the Journal and the website for further details.

Another innovation is a series of "news items". In this issue, details of the proposed REAAA Mino Roadshow are announced, together with details of the New Zealand Chapter's 'Technical Paper Award' competition. A series of short articles outlining the results of recent research are also presented. All Chapters are actively encouraged to submit items of interest for publication in future editions of the Journal. Members representing organisations involved in applied research and development are also invited to submit news items of this type.

The Editorial Board is actively seeking papers for publication in the Journal, together with general news items and details of forthcoming Conferences. The revised membership of the Editorial Panel is given below.

Kieran Sharp
Chairman REAAA Technical Committee

New Zealand's Performance Specifications for Design and Construction of Unbound Granular Pavements

Dr Bryan Pidwerbesky
Fulton Hogan Ltd

David Alabaster
Transit New Zealand

ABSTRACT

Traditional specifications for pavement materials and construction are recipe based and somewhat restrictive, so performance based contracts are being progressively introduced in New Zealand to provide contractors with an opportunity to be innovative and to assume greater responsibility (and risk) for road construction projects. A performance based specification for the structural design and construction of thin-surfaced flexible unbound granular pavements, including surfacing, was introduced as a provisional document in 2000, to foster innovation in using marginal and non-conforming materials that give similar performance to standard basecourse and subbase materials. Another objective is to preserve prime quality aggregates, so that road construction is achieved in a sustainable manner that mitigates any adverse environmental effects.

Two projects completed under this performance-based specification are described as case studies, including both the innovations and how research was put into practice. The paper includes the respective views of the contractor and highway authority as to the experiences gained from the two projects described in the paper, and the benefits of performance based specifications. It is intended to provide an insight into the process so that other road authorities might also adopt performance-based specifications for road construction, to allow best use of local resource to achieve the required pavement performance.

1. INTRODUCTION

The New Zealand road network totals nearly 100,000 km in length, of which 55,000 km have all-weather surfaces, and serves a population of 4 million over an area of 268,675 km^2. The typical pavement consists of a sprayed chip seal over unbound granular base and subbase layers. The pavement engineering design and construction practices employed in New Zealand are described elsewhere (Austroads 1992; Transit NZ 2000a; Transit NZ 1997).

The thickness design procedure for thin-surfaced, unbound granular flexible pavements is based on the Austroads (1992) Pavement Design Guide (Austroads is the association of Australian and New Zealand state highway authorities). The procedure assumes that the surface thicknesses of less than 35 mm do not contribute to the structural capacity of the pavement and that the stresses are dissipated through the depth of the granular cover layers above the subgrade. The design theory presupposes that the primary mode of structural failure is permanent deformation in the subgrade, so the main criterion is to limit the vertical compressive strain in the subgrade to acceptable magnitudes (Pidwerbesky 1995a).

New Zealand's highway authority (Transit) does not want to develop new pavement material and construction specifications for every possible alternative material. However, to encourage innovation and to give contractors the opportunity to trial new materials, Transit has developed performance based specifications. These specifications set out the requirements for materials and road performance (e.g. rutting, roughness etc) at the end of the defects liability period, usually 1 to 3 years after the road has been opened to traffic. The objective is to allow a pavement to be built utilising a wider range of materials, provided it can be shown that these materials have adequate strength and durability for the design life.

The benefits of performance specifications compared with end-product and recipe-type specifications include (Arnold 2000):

- the provision of a contractual environment that encourages innovation
- utilising contractor's experience;
- focusing the client on performance rather than historical empirical relationships; and
- apportioning the risk between client and contractor appropriately.

Risks for the Road Authority in using performance based specifications include:

- engaging a contractor who is unable, or unwilling, to construct the pavement to the specified quality; and
- paying for a product that does not meet the long term performance expectations.

The risks can be mitigated by:

- mutual understanding between the Road Authority and contractor of the elements of the performance based specifications;
- mandatory quality assurance requirements; and
- good prediction of long term behaviour.

The effects of performance based specifications are wide reaching and roles change significantly. The contractor is required to possess or out-source skills such as pavement design and advanced materials testing. The Road Authority's role changes from designer/supervisor to that of quality auditor.

1.1. Performance Requirements

The aim of developing performance requirements for the structural design and construction of flexible unbound pavements is to have a more direct relationship to required in-service performance. In an unbound pavement, the basecourse and subbase materials are required to:

- spread the wheel loads to reduce the load on the soft underlying subgrade and/or other weaker pavement materials;
- not fail in shear (i.e. shoving or rutting) with the application of wheel loads;
- have minimal deformation, where most of the deformation occurs in the subgrade;
- not deteriorate structurally over the design life;
- adequately hold and support the surfacing; and
- not be detrimental to the performance of the surfacing (e.g. cracking).

The requirement to adequately spread the load over the subgrade is currently ensured by providing adequate pavement thickness as determined using the pavement thickness design procedures in the Austroads (1992) Pavement Design Guide. Traditionally all the other requirements listed are satisfied by using an unbound granular aggregate that complies with New Zealand's material specification for basecourse aggregate, M/4 (Transit NZ 1995). This specification is a recipe for quarries to make a basecourse that has been proven over time to provide adequate performance in the road.

Materials that are less costly to produce than those complying with M/4 can meet the six requirements. New Zealand's performance based specifications B/3 (Transit NZ 2000*b*) and M/22 (Transit NZ 2000*c*) provide a framework to allow these materials to be evaluated and used.

2. B/3 SPECIFICATION AND M/22 NOTES

The *Performance Based Specification for Structural Design and Construction of Flexible Unbound Pavements* (referred to as B/3) (Transit NZ 2000*b*) has been developed to evaluate whether a pavement is meeting the six performance requirements stated above, at the end of its maintenance period; the acceptance criteria are set at a level that gives confidence the pavement will give adequate service over its design life. Specification B/3 requires evidence that the materials used in the pavement have adequate strength and durability for the design life requested by the client before construction begins. *Notes for the Evaluation of Unbound Road Base and Subbase Aggregates* (referred to as M/22 Notes) (Transit NZ 2000*c*) were developed to provide guidelines for providing that evidence. The M/22 Notes are not mandatory, and other supporting information proving the suitability of a material, such as road tests, may be adequate to allow their use. Specification B/3 also includes a number of checks at intermediate points in the design and construction processes to ensure that the pavement is designed and constructed in a manner that is likely to produce the desired performance. The process followed by the Contractor and Engineer is detailed in *Table 1*.

2.1 Basecourse Requirements

M/22 (Transit NZ 2000*c*) uses the generally accepted definition of a basecourse as "the pavement material (stabilised or otherwise) forming the base, defined as the upper 100 mm to 200 mm of aggregate in a thin surfaced (less than 35 mm) pavement". The traffic induced stresses are greatest in this top part of the pavement. Therefore the highest shear strength and durability is specified for the basecourse.

The basecourse is required to be unbound to ensure shrinkage and tensile fatigue cracks do not reflect through the surfacing. Any stabilised materials used as a basecourse will undergo a tensile strength and linear shrinkage test. The stabilised material will not be accepted as a basecourse unless the tensile strength and shrinkage are below specified maximum values. Thus, this will normally limit the amount of cement added to a maximum of 2%.

To ensure the basecourse has sufficient durability and weathering resistance, the source rock is required to have the same crushing and weathering resistance as is required for high quality crushed rock complying with M/4 (Transit NZ 1995). Often marginal aggregates will fail the weathering and crushing resistant requirements. A stabilising agent (e.g. cement) can be added to overcome this deficiency. The aggregate stabiliser combination is then tested using the ASTM D 559-96 *Standard Test Methods for Wetting and Drying Compacted Soil-Cement Mixtures.* Compliance is achieved if no more than 20% of material loss occurs after 12 cycles of the wet and dry test.

In M/22, in-service shear strength and deformation resistance of proposed aggregates can be proven by:

- laboratory testing with the Repeat Load Triaxial (RLT) test;
- full-scale testing at New Zealand's accelerated pavement loading facility (CAPTIF) which is described elsewhere (Pidwerbesky 1995*b*); and
- acceptable performance on roads with documented maintenance and loading histories.

The Repeat Load Triaxial (RLT) test equipment applies a pulsating stress on the basecourse sample to simulate the passage of one set of duals tyres with a standard 8.2 tonne axle load. Aggregate is tested in the RLT apparatus for 100,000 load cycles and the permanent deformation during the test is recorded. The test conditions simulate the worst in-service conditions. This could be saturated undrained at the maximum stress (load) conditions expected in service being applied. Materials that fail this test are those that have an increasing rate of deformation with increasing load cycles. The contractor has the flexibility to vary the RLT test parameters as they are required to guarantee the performance of the road for the specified defects liability period of 1 to 3 years. Alternatively, full-scale testing can be conducted at New Zealand's accelerated pavement testing facility, CAPTIF (Pidwerbesky 1995*b*).

Acceptable performance on other roads requires independent and accurately documented maintenance and loading histories on a pavement in a similar environment. It would be necessary for the trials to have accurately recorded the maintenance history of the pavement and the change over time of parameters such as roughness and rutting. It would also be essential that the loading history was accurately known with actual measurements made of axle loadings.

A minimum soaked California Bearing Ratio (CBR) of 80% has also been specified. This allows the CBR test to be a screening test for materials being proposed as a basecourse before undertaking the RLT test.

2.2 Subbase Requirements

TNZ M/22 defines the subbase as any pavement material below the basecourse and above the subgrade or subgrade improvement layer. The overlying basecourse reduces the traffic induced shear stresses in the subbase significantly and therefore the requirements are less stringent.

The specification allows the use of more than one subbase material and recognises that the strength requirements for these materials are governed by their position in the pavement (depth) and strength assumed for design. As with the basecourse, M/22 requires that the subbase be durable and strong; however it can, unlike the basecourse, be bound.

Using bound layers in the subbase is acceptable as the unbound overlying basecourse material will prevent any cracks occurring in a subbase material reflecting through to the surface. Therefore, there are no limits placed on the tensile strength or shrinkage of the subbase material. This allows a subbase to be a bound material should the design utilise a bound layer (modulus 2000 MPa) within the pavement.

To ensure the subbase has sufficient durability and weathering resistance, the source rock is required to have a minimum crushing and weathering resistance similar to M/4 (Transit NZ 1995), but with a lower load in the crushing resistance test. Should the source rock not meet the weathering requirements then the stabilised material is tested for weathering using a wet and dry brushing test as required for the basecourse.

In terms of strength requirements, a minimum soaked CBR of 30% has been specified for subbases, considered in the design as unbound, that are directly below the basecourse. For other subbases the

Table 1

Step by Step Process for TNZ B/3 Performance-Based Contracts

Contractor	Engineer (client)
1. Prior to any roading projects being advertised, the Contractor in liaison with local quarries should source appropriate pavement materials (modified or otherwise) and test for compliance with TNZ M/22 *Notes for the Evaluation of Unbound Road Base and Subbase Aggregates.*	2. Site investigation: subgrade strength tests deflection tests site survey
	3. Initial geometric and pavement design to do cost estimate.
	4. Produce tender documents to include: • drawing showing plan (horizontal alignment) • site data as detailed in Schedule A • design subgrade strength for each road section • explanation as to how to calculate material volumes
	5. Advertise tender for contract.
6. Receives tender documents and proceeds to: • source appropriate pavement materials (as above); • design pavement cross sections based on site data given in tender documents, and check for compliance with Austroads (1992) and NZ Supplement (2000a); • design first seal coat; • determine total costs; and • complete other tender requirements.	
7. Submit tender which includes amongst other things the following: • pavement design cross-sections; • pavement materials to be used (include info needed to identify the material types, eg grading) with evidence of compliance with M/22 Notes; • a Quality Plan for construction which includes targets for compliance with appropriate tests. • unit rates and total cost needed for payment.	
	8. Evaluate tenders including: • checking that the pavement design cross-sections meet or exceed the design life when evaluated using Austroads (1992) procedures; • check the pavement materials to be used comply with M/22 Notes; • chooses and notifies the Contractor;
9. Proceeds on site and undertakes site investigation. • obtains agreement with Engineer if site data has changed and then re-designs pavement cross-section.	
	10. Checks any changed pavement design meets or exceeds the design life when evaluated using the procedures in Austroads (1992)
11. Proceeds to Construct the pavement to their Quality Plan. • undertakes construction and maintenance to meet the requirements of the specification	
	12. At appropriate times the following items are checked: During construction: • pavement materials used are correct; • pavement depths achieved; • pavement layers are compacted to their target densities. On finished pavement prior to sealing: • pavement stiffness are achieved; • construction tolerances are complied with; • surface shape and rut depth is acceptable; roughness is acceptable; • saturation level is acceptable.Soon after first coat seal is applied: • texture depth, chip retention, surface water-proofness is acceptable. At the end of the defects liability period (1 to 3 years): • surface shape and rut depth is acceptable; • roughness is acceptable; • texture depth, chip retention, and surface waterproofness are acceptable

minimum soaked CBR is governed by the amount of overlying material and design traffic as determined using the Austroads (1992) thickness design chart for unbound granular pavements. If the pavement design requires a bound subbase of a certain modulus then this will govern the minimum Unconfined Compressive Strength (UCS) based on a relationship between modulus and UCS in Austroads (1992).

2.3 Discussion

Specification B/3 provides the framework to reduce the risk to the client of using new and innovative materials by focussing on the performance of the pavement at the end of its maintenance period rather than the materials and processes that go into a producing that pavement. The performance criteria listed in B/3, if achieved at the end of the defects liability period, give confidence that the pavement will perform adequately for its design life. In addition, there are a number of intermediate checks which are actually either based on the Contractor's quality assurance plan or intermediate steps prior to the final acceptance criteria at the end of the defect liability period (1 to 3 years) – these checks are presented in Step 12 of *Table 1*.

The major risk to the client and contractor is the inadequacy of currently-available techniques for predicting pavement performance, both for the materials prior to construction and for the pavement immediately after construction. Procedures for predicting field performance, especially for recycled or other marginal materials, must be improved.

M/22 does not specify the use of any stabilisers, grading requirements or number of crushed faces, for example. It is the contractor's responsibility to provide a material that will meet the specified durability and strength requirements. The materials that meet the basecourse and subbase requirements will range from the unconventional to minor changes from traditional specifications such as M/4. Cost, availability and risk will be the driving factors as to the type of material chosen.

3. CASE STUDIES

To date three pilot projects using B/3 (Transit NZ 2000*b*) have been completed. On the first project, a realignment on State Highway 22 south of Auckland, construction was completed in 2001 and project defect liability period ended in 2002. The second project, the realignment on State Highway 6 in the South Island, was completed in April 2002, and completed its defect liability period (12 months) in April 2003. Construction of the third project, the Napier Hawkes Bay Expressway on the East Coast of the North Island, was completed in May 2003, which was followed by a 12 month defect liability period. The second and third projects are discussed below.

3.1 Case Study 1: Glenhope Project

Fulton Hogan was contracted by Transit New Zealand to construct 10 km of road realignment on State Highway 6 from Glenhope to Kawatiri, located 80 km south of Nelson in the South. The project construction period was 21 months and the project was officially opened on 19 April 2002, 3 months ahead of schedule.

The new alignment includes 2 km of passing lanes which has improved the driving alignment to a speed environment of 75 km/h. The improved alignment has eliminated a number of accident "black spots". A total of 4 km of the project passes through Kahurangi National Park, so this required some additional attention to environmental issues.

Local aggregates are alluvial deposits from the Buller River; the Gowan quarry is approximately 10 km south of the site. Thus, Fulton Hogan undertook a significant amount of investigation and laboratory work to establish the suitability of modified local basecourse products compared to aggregate that complies fully with M/4 (Transit NZ 1995). The testing included RLT testing. Several options on local basecourse specifications were presented with the tender.

Pavement Requirements and Design Parameters

State Highway 6 had an Annual Average Daily Traffic (AADT) count of 1500 vehicles per day (veh/day), and 12% heavy vehicles. For the required 25 year design life, this equated to a design traffic loading of 1.7×10^6 equivalent single axle loads (ESA).

The assumed subgrade strength from earlier geotechnical investigations conducted at the feasibility stage of the project was a design subgrade CBR of 8. The modulus of the basecourse aggregate was 400 MPa for pavement design.

Manufacture of the Basecourse Aggregate

Manufactured properties of the proposed quarry material were tested. The only substantial variation from the M/4 specification for basecourse aggregate was the Broken Faces criteria. Normally, in order to comply with M/4, 70% of the particles larger than 4.75 mm in basecourse aggregate must have broken faces. Research conducted at New Zealand's accelerated pavement test track had confirmed that, for State highways carrying low volumes of traffic, the percentage of broken faces in the basecourse aggregate could be reduced without significantly affecting the performance of the pavement (Pidwerbesky 1995*b*). For this project, a minimum of 60% and 40% in the 37.5 to 19 mm and 19.0 to 4.75 mm fraction sizes, respectively, were the contractor's nominated criteria for the basecourse. For all other properties specified in the contractor's quality plan, the alternative material used for the basecourse met or exceeded the minimum requirements of M/4.

The alternative material had a CBR of greater than 135 (M/4 requires a minimum CBR of 80%), and a modulus of 450 MPa (for RLT test conditions of 425 kPa deviator stress and 125 kPa confining pressure).

Manufacture of the subbase and basecourse aggregates was all conducted at the local quarry. The quarry has stratified layers of glacial and alluvial deposits. Large boulders in a sand and gravel matrix overlie finer gravel and sand layers. The excavator also mixed the material to ensure it was relatively homogeneous prior to crushing.

The crushing processes that would have been necessary (to fully comply with M/4) compared to what was required to achieve the specifically designed aggregate material are illustrated in *Figure 1*. The saving of 30,000 m^3 of raw feed had significant economic advantage as well as environmental benefits as that quantity of material is still in the pit that otherwise would have had to be quarried and wasted (there is no potential market for utilising this waste within an economical haulage distance of the pit).

Construction

After compaction, the subgrade tests included nuclear density meter every 50 m, dynamic cone penetration (DCP) every 50 m in each lane, and Benkelman Beam deflection every 40 m in each wheelpath in each lane. This extensive testing regime was done to ensure that the subgrade condition was suitable for the pavement design above it; maximum allowable values for the deflection and DCP results were 2 mm and 25 mm/blow, respectively. If the subgrade was deficient, remedies included additional compaction and replacement of the material and re-compaction. As a last resort, a third option was to increase pavement layer thicknesses, but this was not required.

Pavement construction was carried out using conventional equipment and techniques. The specified material was generally a very good material to lay and productivities were no different to what they would have been laying standard M/4-compliant material. The material required six passes of the rollers to achieve the compaction density. The pavement laying conditions specified in the contractor's quality plan were all achieved.

The primary acceptance criteria for the completed basecourse, as far as the contractor's pavement designer was concerned, was a Benkelman Beam deflection of less than 1 mm and a coefficient of variation of less than 25% (coefficient of variation is the standard deviation of a sample of date divided by the mean of that data, and is a measure of uniformity).

The wearing course was a two coat (14 mm and 7 mm) chip seal. B180-penetration grade cutback bitumen was sprayed at a residual application rate of 1.8 L/m^2.

Post Construction Pavement Performance

The acceptance criteria for pavement performance after one year were:

❑ Rutting	Maximum rut depth of 10 mm
❑ Texture Depth	Minimum 1.0 mm
❑ Skid Resistance	Minimum Grip Number 0.60 (or SFC 0.60)
❑ Roughness	Maximum 70 NAASRA counts/km (IRI 2.7) for a 100m section, and average of 55 NAASRA counts/km (IRI 2.1) over project length.

Results to date indicate excellent pavement performance.

Texture Depth and Skid Resistance

The texture depth of the finished seal was measured every 80 m in each wheelpath of each lane and centreline during the maintenance period (post construction) using the sand circle test (Transit NZ 1981), and was in the range of 1.0 to 2.0 mm, with an average of 1.34 mm. The second set of texture depth measurements were done in April 2003, and the average texture depth had decreased to 1.26 mm, which was substantially greater than the acceptance criteria of 1.0 mm.

The first high speed data (HSD) survey done by the highway authority, in February 2003, ten months after the pavement was surfaced, showed that the average surface texture depth over the length of this project was 1.65 mm. The HSD survey uses lasers mounted on vehicles travelling at normal highway speeds, so the HSD results do not compare directly with the manual sand circle test results. The HSD lasers measure texture continuously and results are an average of the data every 10 m.

Fulton Hogan owns and operates a D-type GripTester, which was used to test the skid resistance of the entire length during the maintenance period, and the GripNumber was in the range of 0.7 to 0.8, which is an excellent friction value. Regular skid resistance measurements will be done as part of the normal skid resistance survey conducted annually by Transit NZ over the entire national highway network.

Roughness and Rutting

As part of this trial of the B/3 process, Transit NZ and Fulton Hogan collaboratively measured the roughness of pavement sections prior to sealing, using a Dipstick Profiler. However, due to the time required to conduct this test and the relatively large variations in the results – due to the normal irregularities in the surface of an unbound pavement – this 'experiment' was concluded early in the project. Subsequently, roughness values for the sealed pavement were extracted from the normal high speed data survey conducted by Transit NZ annually. The roughness over the length of the project averaged 54 NAASRA counts/km (IRI 2.1), 10 months after opening to traffic.

The rut depths were measured using a manual method every 50 m, four months and 12 months after construction. Average rut depths have also been extracted from Transit's annual high speed data (HSD) survey conducted ten months after construction. As with all unbound granular pavements subjected to heavy vehicles, the rate of initial rutting under trafficking immediately after construction is relatively high, but soon levels off to the secondary rate of rutting. Because the two sets of measurements were not conducted at the same time, the difference in the two means (HSD vs manual) cannot be compared. However, the differences in the standard deviations could be compared, and this showed a significant difference between the two measurement techniques. Even though manual rut depth measurements are more costly, this form of measurement is probably more acceptable as a performance measure.

Statistical Analysis of Deflection Data

A primary indicator of pavement stiffness (and, thus, its expected performance) is its deflection under load. Therefore, an extensive programme of Benkelman Beam deflection testing was carried out on the subgrade and pavement layers, with deflections measured every 40 m in each wheelpath of each lane plus along the centreline. B/3 (Transit 2000b) required that 95% of the values measured in a typical 1000 m^2 lot were to be better than or equal to the target values. However, this still allows for very poor sections to be accepted. One technique to improve this is to apply a more rigorous statistical analysis. In addition, this statistical analysis can assist in determining a suitable testing regime for future projects.

The mean pavement deflection was calculated at each chainage by averaging all transverse positions (that is, each wheelpath in each lane plus the centreline). The target deflection was 1 mm; 99% of the mean deflections were below 1 mm, while 94% were less than 0.8 mm. Standard deviations for the subgrade and pavement deflections were 0.43 mm and 0.19 mm, respectively. As expected, the surface deflections were much more consistent than the deflections in the subgrade, yielding a much smaller standard deviation for each individual section of road as well as for the entire road.

The number of tests required to achieve a statistical level of confidence levels was also determined. The maximum number of deflection tests in any 1 km section of road required to provide a 90% confidence level is 17 per wheelpath, but on average only 10 deflection tests are needed. For a 95% confidence level the average maximum number of tests required was 38 per km. Thus, a 90% level of confidence can be statistically validated by testing deflections every 100 m in each wheelpath.

The confidence intervals used for determining the number of tests required are one-tailed, because no lower limit is required for allowable deflection. In other words, if sampling is carried out using the number of tests specified, then there will be a 90% (or 95%) certainty that the results will be less than the target.

In proposed revisions to the B/3 Specification, the requirement that 95% of the material used is better than the target values will be removed and a more rigorous approach will be adopted. Statistical analysis techniques are a valuable tool for both the contractor and Road Authority in quantifying the condition of the pavement and verifying compliance with acceptance criteria.

3.2 Case Study 2: Hawkes Bay Expressway Project

This project extends from the Hawkes Bay Airport on State Highway 2 for 5.3 km. The major items being built included:

- 5.3 km of two lane sealed road;
- embankment/culvert/bridge crossing over the Ahuriri Estuary;
- roundabouts at the intersections with Tamatea Drive and Taradale Road; and
- 750 m of two-lane arterial road for the Napier City Council.

Construction began in January 2002 and was completed in May 2003.

The contractor generated alternative pavement designs based on the data provided in the Geotechnical Report at the time of tender and some additional material testing that the contractor undertook pre-tender. This alternative offered Transit an economic advantage over the original tender design, provided an opportunity for the contractor and Transit to gain further experience with B/3, and transferred risk associated with granular pavement layers and chip sealing design and construction to the contractor.

The required acceptance criteria are similar to current TNZ granular pavement specifications, except for the subbase thicknesses, and the key pavement strength parameter, once material gradings and compaction densities have been achieved, is the stiffness criteria on individual layers: maximum allowable Benkelman Beam deflections at the top of the finished subgrade and pavement were initially specified to be 1.6 and 0.6 mm, respectively.

Construction Issues

There was some difficulty achieving adequate stiffness in the upper sand-silt subgrade material through cement modification alone, but granular stabilisation of the subgrade improved stiffnesses, so either granular stabilisation alone or combined granular and cement stabilisation was used for the remaining areas of sand-silt subgrade. The significant variability of the subgrade and implications on pavement design are summarized in *Table 2*. Due to the extremely poor subgrade conditions in some sections of the road, the maximum allowable deflection for the finished pavement in these sections was relaxed to 1 mm (from 0.6 mm), but only if a coefficient of variation of 20% or less was achieved, to ensure that the pavement is uniform and excessive roughness will not occur prematurely under trafficking.

This project has highlighted the deficiencies of relying on nuclear density meters for determining compaction densities. Due to the highly variable nature of the insitu subgrade material, in situ densities were regularly checked using sand displacement method, and both solid densities and maximum dry densities were determined at a much higher frequency than the norm for New Zealand State highway construction, at the instigation of the contractor, in order to mitigate the contractor's risk.

Discussion

In order to construct the Hawkes Bay Expressway within the contract price, the contractor took advantage of its national expertise, conducted trials to confirm local materials, modified designs and construction techniques during construction, and optimised allocation of resources and equipment. However, substantial additional costs were incurred due to waiting for the outcomes of the trials and additional testing required.

A significant aspect of ensuring the successful implementation of performance specification is the culture change required of both contractor and client. Key staff, such as engineers and supervisors, must be fully briefed and trained, so that they use the correct approach and understand their respective roles in performance contracts.

4. SUMMARY AND CONCLUSIONS

New Zealand's B/3 performance based specification for the structural design and construction of flexible unbound pavements, including chip seal surfacing, was introduced in 2000 to foster the use of marginal and non-conforming materials that give similar performance to standard basecourse and subbase materials. This paper has provided an overview of B/3 and its accompanying document for materials, M/22 *Notes for the Evaluation of Base and Subbase Aggregates*, as they are and proposed improvements. To date three pilot projects using B/3 have been completed; details of two of these projects have been presented as case studies, and the relevant outcomes of each project discussed.

Table 2
Subgrade Variability and Pavement Design

Location Relative to Estuary	Subgrade	Lower Subbase	Upper Subbase Thickness (mm)	Base Thickness (mm)	Total Pavement Thickness (mm)	Revision	Design Code
North (6.5 x 10^6 ESA)	granular CBR = 15		140	150	290		A
	CBR = 8	50 mm	140	150	340		B
Zone 3 ch 1250-2000	granular		0	200	200	2	C
Zone 3 ch 1050-1250 & 2000-2100	sand silt	200 mm thick granular layer mixed 250 mm deep into subgrade	0	200	450	5	H
South (3.9 x 10^6 ESA)	subgrade CBR=5	subgrade stabilised with mm 2% cement,200	120	150	470	1	D
Zone 4		75 mm thick granular layer mixed 150 mm deep into subgrade 200 mm	120	150	470	3	E
Zone 6		100 mm thick granular layer + 2.0% cement mixed 230 mm deep into subgrade 200 mm	0	200	400	6	G
Zones 5 & 7		75 mm granular overlay + 2.0% cement mixed 200 mm deep into subgrade	0	265	465	4	F

Revision Details

1 1/5/02 Revised subsequent to site information that subgrade modified with 2% cement yielded soaked CBR of 14% and that the unmodified insitu subgrade yielded soaked CBR of 9%.

2 10/9/02 Due to high quality subgrade, pavement reduced to 200 mm of M4 in Zone 3.

3 10/9/02 Granular stabilisation approved as technique to improve subgrade in lieu of cement stabilisation.

4 7/11/02 Superseded change made in revision 5 (above). Subbase replaced with M/4 to further increase confidence of performance.

5 7/11/02 For areas where sand silt exists in subgrade. Overlay subgrade with 200 mm of granular then mixed 250 mm deep.

6 2/12/02 Supersede revision 4 above. Further improved stabilised layer by increasing cement content to 2% and treat to 250 mm.

Under the B/3 contract, the contractor is responsible for the design, construction and maintenance of the pavement and seal. The contractor has to demonstrate that design, materials, and construction techniques are appropriate by their quality assurance systems and that the pavement performance at the end of the defects liability period (1 to 3 years) is acceptable. The following are checked to ensure that the performance criteria for the road have been met:

- ❑ surface and rut depth;
- ❑ roughness;
- ❑ texture depth;
- ❑ skid resistance;
- ❑ surfacing aggregate retention; and
- ❑ surface waterproofness.

Contractors undertaking work involving performance-based specifications require highly skilled and experienced pavement designers (either in-house or out-sourced); the Road Authority must also possess (or, at least, have access to) experienced, knowledgeable pavement engineers in order to be able to adequately assess submitted proposals.

The contractor completed an extensive suite of tests on the subgrade and pavement layers during and after construction, and analysed the data to determine statistically valid testing regimes for future projects. Statistical analysis techniques are a valuable tool for both the contractor and Road Authority in quantifying the condition of the pavement and verifying compliance with acceptance criteria, and should be an integral facet of performance-based contracts.

Road Authorities and industry must collaborate, including sharing knowledge and expertise, in order for performance-based specifications to be successfully introduced and implemented. These parties must also work together to ensure that pavement research is relevant to their needs; better, more accurate and robust (but not complex) techniques must be developed for predicting pavement performance, so that the risks for the contractor and the road authority can be more readily quantified.

In addition to potential economic advantages, performance-based contracts can also preserve prime quality aggregates, so that road construction is achieved in an environmentally sustainable manner.

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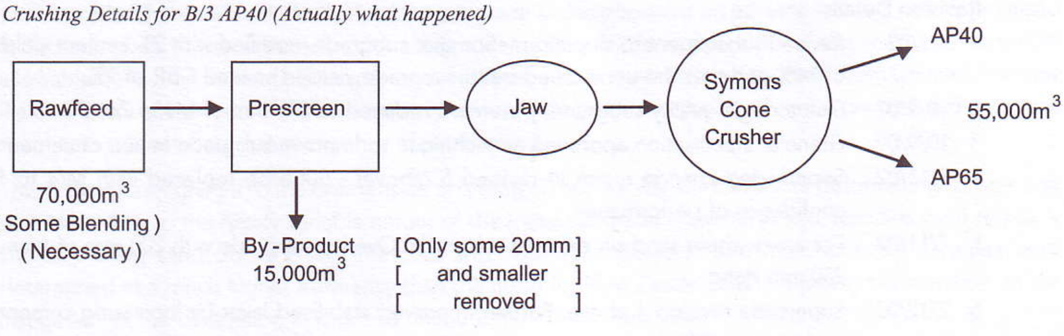
1. *Crushing Details for B/3 AP40 (Actually what happened)*



2. *Crushing Details for M/4 (What it would have been if we had to make M/4)*

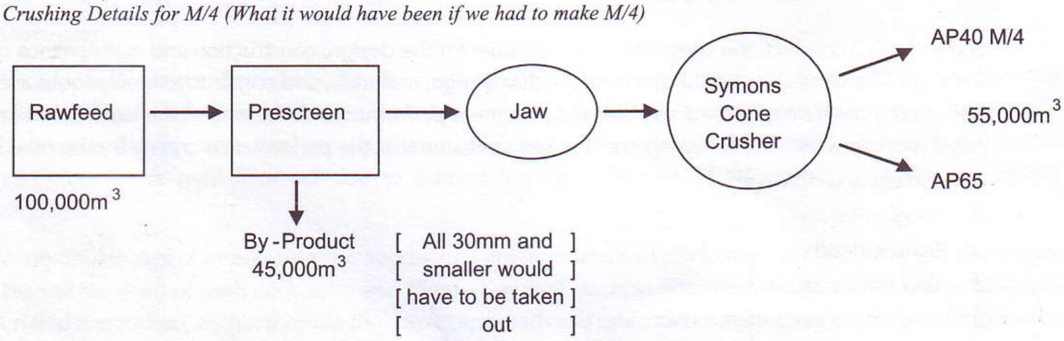


Figure 1: Aggregate Production Process for Case Study 1

Willingness of Drivers to Pay for Transport Information in Malaysia

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ABSTRACT

Vehicle traffic has become the chief cause of transport inefficiency in urbanized areas, where many conflicting users must share the limited road space. In addition, adverse effects of vehicular traffic such as accident and air pollution have created various social problems. In many cases, these problems cannot simply be overcome by providing new roads, due to the lack of available space. The solution therefore lies in traffic management, which includes the provision of traffic information to road users. Malaysia is a developing country aiming to achieve the status of a developed nation by the year 2020. The country, especially the Klang Valley Area (which is the focal point of economic and political activity), is now experiencing an increase in traffic volume. As a result of the rapid growth in vehicle ownership and other related issues, serious levels of congestion exist everywhere in the city. One solution to the traffic congestion problems lies in adapting Intelligent Transport Systems (ITS). This paper describes a study conducted in Malaysia which involved the evaluation of various Integrated Transport Information Systems (ITIS) and the willingness of both private vehicle users and public transport users to pay for this information.

1. INTRODUCTION

Vehicle traffic has become the chief cause of transport inefficiency in urbanized areas, where many conflicting users must share the limited road space. In addition, adverse effects of vehicular traffic such as accident and air pollution have created various social problems. In many cases, these problems cannot simply be overcome by providing new roads, due to the lack of available space. The solution therefore lies in traffic management, which includes the provision of traffic information to road users.

Malaysia is a developing country aiming to achieve the status of a developed nation by the year 2020. The country, especially the Klang Valley Area (which is the focal point of economic and political activity), is now experiencing an increase in traffic volume. As a result of the rapid growth in vehicle ownership and other related issues, serious levels of congestion exist everywhere in the city. One solution to the traffic congestion problems lies in adapting Intelligent Transport Systems (ITS) (Black and Arnold 1991).

The use of ITIS allows drivers to access more, and more accurate, traffic information than was possible in the past. In 1997, JICA (Japan International Cooperation Agency) Malaysia conducted a Study on Integrated Transport Information Systems in the Klang Valley area. It was found that additional built-in sensors would help drivers to avoid collisions. The road network can be utilized more efficiently and vehicle operation can be improved, as more data are available to road administrators and vehicle operators. ITIS can provide information on:

- congestion, and the causes of that congestion;
- route guidance;
- origin-destination;
- driving and road conditions
- roadway hazards; and
- public transport.

In spite of the growth of road traffic, there is no central body that manages the traffic on the road network in the Klang Valley Area. Each road is operated separately by its respective road administrators, either the Federal or Local Government agencies or private entities, and there is very little interaction between them. It is hoped that the introduction of ITIS will provide an opportunity to integrate the operation of the road network in the Klang Valley Area and maximize the efficiency of its use.

In seeking solutions to the present traffic congestion problems, it is necessary to understand the interaction between the information and the route choice of drivers. The shape and location of the Klang Valley Area was strongly influenced

by the public transport systems that evolved over time. To try and resolve the traffic problem of Klang Valley Area, a detailed study needed to be undertaken.

The objectives of the study described in this paper were to rank the various types of information and to determine the preferred method by which this information could be supplied to drivers and public transport users. Another objective was to determine how much drivers and public transport users would be prepared to pay to obtain the information. The study also examined possible future road network scenarios and existing and possible future problems road users may face in relation to ITS. The ITS currently deployed in the Klang Valley Area was also studies. Limitations of the study included the fact that only a limited number of interviews were conducted, and the fact that the interviews were only conducted in the Klang Valley Area.

2. LITERATURE REVIEW

One of the main reasons that ITIS was recommended for the Klang Valley Area was that a large number of benefits, both direct and indirect, can be expected with its introduction. Although it is difficult to quantify these benefits, especially the indirect benefits, experience in other countries suggests that large benefits are associated with the introduction of ITIS.

For example, the Vehicle Information and Communication System (VICS) car navigation system was introduced in Japan in 1996 to provide real-time traffic information to drivers through in-vehicle units. This system was found to be capable of producing benefits amounting to 7.7 trillion Yen (US$63 Billion) over a period of 20 years compared with a total investment of 1.2 trillion Yen (US$9.7 Billion) over the same period (JICA 1997).

Currently no variable message signs are installed along any of the congested roads discussed earlier. Thus, no real time traffic information is given to drivers except for brief traffic reports aired on FM radio in the morning and evening; these are very limited in scope, coverage area and frequency. Very often drivers do not 'learn' of the incident until after they are already stranded in the congestion. If drivers were promptly and properly informed of the incident in advance, they could then take alternative routes, resulting in a very large reduction in travel time. Alternatively, in the absence of an alternative route, drivers could delay their journey and engage in more productive activities until the congestion had eased.

Greenhouse gas effects due to excessive emissions of CO_2 are becoming a serious global environment issue. One of the sources of CO_2 emission is vehicle engines that are powered by gasoline or diesel fuel. The amount of CO_2 emission increases rapidly as the operating speed decreases. Eliminating congestion is an effective way to reduce CO_2 emissions. A recent Japanese study estimated that a 2.7% reduction in CO_2 emissions by vehicles could be achieved with the introduction of a traffic information system to Kuala Lumpur (JICA 1997). In this way, ITIS can contribute significantly to mitigating such global environmental issue.

The existing traffic reports provided by FM radio rely mainly on observations of traffic condition through TV cameras installed at ten locations in Kuala Lumpur. Neither drivers nor road administrators would be aware of any traffic congestion without these cameras. However, the coverage area is limited and no quantitative data such as queue length or travel time is mentioned in the radio broadcasts. Expansion of the system, upgrading of the system functions and wider use of the system are urgently required. Some toll road operators have installed vehicle detectors, TV cameras, and variable message signs on their highways for traffic management purposes. However, the existing system is not designed to provide real-time congestion information.

The SMURT-KL (Strategies for Managing Urban Transport in Kuala Lumpur) Study, conducted by JICA from March 1997 to February 1999, forecast an annual trip production growth of 2.73% for all types of trip purpose in the study area, and an annual average growth of 4.99% for non home based business trips, through to the year 2020 (JICA 1999). Such a rapid growth will impose a heavy burden on the road network and its efficient use will become a crucial issue in the near future. A mid-term review of the Seventh Malaysia Plan 1996-2000 encourages a wider use of ITS to enhance transportation efficiency, safety, comfort and environmental standards.

The relationship between traffic congestion and its causes was explored in an earlier SMURT-KL study and its findings are summarized below.

Two major factors were identified which have induced a car-driven society and created a lifestyle strongly dependent on private cars. These factors are high car ownership and dispersed land-use patterns.

Very high volumes of traffic were observed to enter the Central Planning Area (CPA) daily. A total daily volume close to 1.15 Million vehicles per day was observed to cross the CPA cordon.

A 'sharp peaking' phenomenon was observed for most CPA-bound corridor traffic. Empirical surveys conducted during the JICA Study showed that there is a heavy concentration of traffic into the CPA during a limited morning peak hour, typically between 7.00 a.m. and 8.00 a.m. In the evening peak hour, a more moderate concentration of out-bound traffic was observed. This suggests that people are more flexible in selecting their departure time to return home compared to the morning. The study concluded that, clearly, the main traffic problems were associated with commuting trips to the CPA during a limited morning peak hour.

Many large-scale urban development projects have been planned in Kuala Lumpur. Some of these are under construction, whilst the remainder are expected to be built in the near future. The additional traffic volume to be generated from these large-scale developments is expected to be huge. It has been estimated that the additional traffic generated from these new development projects may account for more than 40% of the total vehicle trips within the CPA and may add another 14% to 15% to the current traffic congestion at the CPA boundary.

Many people have moved away from Kuala Lumpur to the fringe areas (a phenomenon of suburban sprawl) due to urban development, which has changed the residential land-use of the central area in Kuala Lumpur to (dense) business and commercial use. This has accelerated the decline in the residential population in the central area, inducing more people to reside in the suburbs. This is resulting in more people making longer commuting trips.

Application of ITIS takes the form of various user services. User services selected for development and eventual application in any specific region should reflect public needs, technology levels, social framework and role of road transport in that country or region. Thus user service needs in different countries may vary in terms of their content and priority. Some user services are closely related to traffic and transport information, while others are not.

After a careful review of the user services being considered in Malaysia, the USA, Europe and Japan, seven user services were identified as having a close relationship to ITIS, while another three were considered as having a loose relation with ITIS as follows.

User services closely related with ITIS:

- ❑ Pre trip traveller information system.
- ❑ En route driver information system.
- ❑ Traveller service information system.
- ❑ Route guidance system.
- ❑ Parking guidance system.
- ❑ Pubic transport information system.
- ❑ Public transport operation system.

User services loosely related with ITIS:

- ❑ Environmental monitoring system.
- ❑ Commercial fleet management system.
- ❑ Emergency vehicle management system.

3. METHODOLOGY

In the preceding section, ten (10) user services that are either closely related, or loosely related, to ITIS were identified. In this section, some of these user services are selected based on their benefits to the public. They are then further examined for the purpose of setting priorities for their introduction to the study area.

It should be pointed out, however, that discussions on some of the user services in the preceding section are conceptual, covering broad ideas through various media. In addition, different grouping criteria may be applied to define user services. For example, pre-trip travellers and en-route driver information refer to situations where information is provided, while traveller services and parking availability information refer to the specific 'type' of information that each service handles. In terms of system configuration, pre-trip information and traveller services information systems are of the same type but provide different information to different user groups. Likewise, route guidance can be considered as an advanced form of en-route driver information.

Commercial fleet management and bus operations management were excluded from further study because these services are managed by the private sector and they will be the main beneficiary. The factors below are considered when prioritizing user services. It should be noted that cost was not considered as it varied depending on the design and size of the service. It should also be mentioned that any evaluation of user services using these criteria is relative and a simple scoring system was devised to provide a more objective ranking by priority.

The factors to be considered in prioritization criteria are as follows:

- Need for user service.
- Beneficiary and potential amount of benefits
- Information availability
- Technology used
- Ease of implementation

The following factors need to be considered when providing a user service.

- ❑ Clearly, no user service is meaningful if there is no demand for it. One way to determine needs is through an opinion survey, and this technique was adopted in this study. Respondents were asked questions regarding the present situation with respect to traffic information and the type of user services that they would like to have.
- ❑ The benefits of an ITIS user service include a reduction in congestion, travel time and fuel consumption, and an improvement in environment (air pollution, noise and vibration) and traffic safety. The psychological effect of relieving driver frustration is also significant. A user service that generates more benefits is therefore rated as having a higher priority than user service which deliver less benefits. Each user service provides service or benefit to a specific group of road users.
- ❑ Each user service needs information. If reliable information is easily available, then the user service has more chance of success. If necessary and accurate information is difficult, or costly, to obtain, then the establishment of the user service becomes difficult.
- ❑ Advancement in technology has made ITS a reality. Advanced technology may give a positive impact to the local industry and society. ITIS technology, in particular, will assist Malaysia to enter into the information technology society.
- ❑ The successful introduction of a user service depends not only on the technology but also on the social framework in which the system operates. The framework includes the physical condition of the road network, the characteristics of the road traffic, the institutional set-up of road administration, legal issues such as laws and regulations related to road traffic, and the customs and preference of the local people.

The survey preparation involved the development of the questionnaires, sample size determination, and site selection. The questionnaires needed to be simple and easy to understand. It was proposed that 200 drivers and 200 public transport users be interviewed because the information needs of private vehicle drivers and public transport users are different.

3.1 Private Vehicle Drivers

The site survey was conducted at car parks and housing areas in Kelana Jaya, Kajang, Cheras and Puchong (Klang Valley Area). For the private vehicle drivers, four groups of questions were asked as follows.

	Type of Information
1	Seriousness of congestion (heavy, medium, light or no congestion) – (length of queue)
2	Cause of congestion (accident, construction work, flood and etc.)
3	Estimated travel time to reach the destination (in minutes)
4	Route guidance (info on alternative route or fastest route available)
5	Parking location in a certain area
6	Availability of parking

Group I

The information was ranked using the following point system: very important (6 points), important (4 points), average (2 points), and not important (1 point). The average points, and the percentage rates, was calculated ranking of the information developed.

Groups	Very Important (A)	Important (B)	Average (C)	Not Important (D)
Given Points	6.0	4.0	2.0	1.0
Range of Ranking	5.0 or more	3.5 to 4.9	2.1 to 3.4	2.0 or below

Group II

The purpose of these questions was to determine how much private vehicle drivers were willing to pay for each information type if the traffic information can be provided. The type of information that would be provided areas follows:

	Type of Information
7	How congested a road is (heavy, medium, light or no traffic jam on the road)
8	Cause of congestion (accident, construction work, vehicle breakdown, flood and etc.)
9	How long it will take for you to reach a destination (in minutes)
10	Advise you on the route that you should take (information on which is the fastest route)
11	Provide you information on the parking areas in an area (where you can park in a area)
12	Information on which parking areas still have spaces available and which are already full

The average amount that drivers were willing to pay for each information type was then determined.

Group III

	Type of Device
13	Radio broadcasting
14	Telephone inquiry where you can call and obtain traffic information
15	Fax service where you can request for latest traffic info using fax
16	Internet facilities where you have a website providing latest traffic information

The type of device was ranked using the following point system: high preference (5 points), average preference (3 points) and low preference (1 point). The points were averaged and the percentage calculated, following which the devices were ranked.

Groups	High Preference (A)	Average Preference (B)	Low Preference (C)
Given Points	5.0	3.0	1.0
Range of Ranking	3.5 or more	2.1 to 3.4	2.0 or below

Group IV

	Type of Device
17	Message sign placed along the road which continuously provides latest traffic information
18	An electronic board which shows the whole road network
19	A navigation system placed inside your car
20	Radio broadcasting
21	Roadside broadcasting (a particular frequency on the radio providing traffic information as you travel along a road)

The types of device were also ranked using a similar point system: high preference (5 points), average preference (3 points) and low preference (1 point).

Groups	High Preference (A)	Average Preference (B)	Low Preference (C)
Given Points	5.0	3.0	1.0
Range of Ranking	4.0 or more	3.1 to 3.9	3.0 or below

Finally, analysis was conducted to ascertain when private vehicle drivers prefer to obtain traffic information, i.e. either prior to driving or while driving.

3.2 Public Transport Users

The sites selected for the surveys of public transport users were bus stops, LRT stations, and Komuter Stations mainly encompassing the areas of Kelana Jaya, Kajang, Cheras and Puchong (Klang Valley Area). Four groups of questions were again asked as follows.

Group I

	Type of Information
1	Route information at bus – stops
2	Route information at terminals
3	Information on arrival times of buses and waiting times at bus – stops
4	Information on arrival times of buses and waiting times at bus terminals
5	Integration of the operations between various modes of public transport
6	Integration in the ticketing system on all public transport

The scoring and analysis was the same as for private vehicle drivers.

Groups	Very Important (A)	Important (B)	Average (C)	Not Important (D)
Given Points	6.0	4.0	2.0	1.0
Range of Ranking	5.0 or more	3.5 to 4.9	2.1 to 3.4	2.0 or below

The Group II questions determined how much public transport users were willing to pay for type of each information if it could be provided. The questionnaires would normally inquire how many cents are public transport users willing to pay. The type of information that would be provided is based on Group I. After this, the average amount that public transport users are willing to pay can be determined.

The Group III questions sought public transport users preferences as to the type of device they would prefer to obtain the information (at the home or before they start their trip). The type of devices that could be used were the same as for the private vehicle drivers. The types of devices were ranked using the same system as for private vehicle drivers. However, the range of rankings was different as shown below.

Groups	High Preference (A)	Average Preference (B)	Low Preference (C)
Given Points	5.0	3.0	1.0
Range of Ranking	3.5 or more	2.1 to 3.4	2.0 or below

For Group IV, the questions are about the preferred device among public transport users to obtain information while they are travelling. The type of devices that could be provided are tabulated below.

	Type of Device
12	Changeable message sign at the terminal
13	Electronic board display at bus – stops
14	Exclusive traffic information station (Roadside broadcasting)
15	Internet facilities
16	Automatic telephone inquiry
17	Fax services

The types of devices were also ranked using a similar point system to the above with a different range of rankings as shown below.

Groups	High Preference (A)	Average Preference (B)	Low Preference (C)
Given Points	5.0	3.0	1.0
Range of Ranking	4.0 or more	3.1 to 3.9	3.0 or below

Finally, based on the preference on the type of device considered important by public transport users to obtain traffic information, it was determined whether the preference was to obtain the information prior to the trip, or during the trip.

4. RESULTS AND DISCUSSION

4.1 Road Users Awareness and Opinions on ITIS

As already discussed, various types of land uses were selected to allow the collation of opinions from all groups of road users. The selected land uses for the private vehicle users included housing areas, offices, shopping complexes, and colleges, whilst the surveys of public transport users focused on locations such as housing areas, transport terminals such as LRT and Commuter stations, and bus stops. The best returns for the surveys were obtained from the housing areas, car parks, transport terminals and bus stops, while offices provided the lowest return.

4.2 Private Vehicle Users

4.2.1 Importance of Different Types of Information

Drivers perceive the importance of various types of traffic information differently. Conversely, various types of traffic information may be of different significance to a particular driver. Tables 1 and 2 provide a ranking by relative importance and the average points score for each type of information.

Table 1: Ranking of Relative Importance of Information: Private Vehicle Users

	Type Of Information	Very Important or Important (%)	Average Important (%)	Not Important (%)
1	Seriousness of congestion (heavy, medium, light or no congestion)	94.0	6.0	0
2	Cause of congestion (accident, construction work, flood and etc.)	68.0	30.0	2.0
3	Estimated travel time to reach the destination.	50.0	41.0	9.0
4	Route guidance (info on alternative/fastest route available)	83.5	12.0	4.5
5	Parking location in a certain area	69.5	26.5	1.0
6	Availability of parking	64.0	29.5	6.5

Table 2: Average Point Scores: Private Vehicle Users

Rank	Type Of Information	Average Points	Important Ranking
1	Seriousness of congestion (heavy, medium, light or no congestion)	5.000	Very Important
2	Route guidance (info on alternative route or fastest route available)	4.415	Important
3	Cause of congestion (accident, construction work, flood, etc.)	3.930	Important
4	Parking location in a certain area	3.800	Important
5	Availability of parking	3.550	Important
6	Estimated travel time to reach the destination.	3.320	Average Importance

An overwhelming majority of those interviewed considered information about the level of congestion to be the most important information that needed to be supplied, followed by route guidance information, the cause of congestion and parking information. Information on parking (which ranked fourth) and the availability of parking (ranked fifth) was considered to be important. The estimation of travel time was ranked sixth and was only considered to be of average importance.

Table 3 presents information regarding the willingness to pay for the different types of traffic information. The average amount that the private vehicle users were willing to pay for each type of traffic information is presented in *Table 4*.

Table 3: Proportion Respondents Willing to Pay for Traffic Information; : Private vehicle Users

Rank	Type Of Information	Willing to Pay (%)	Not Willing to Pay (%)
1	Seriousness of congestion (heavy, medium, light or no congestion)	84.5	15.5
2	Route guidance (info on alternative route or fastest route available)	77.0	23.0
3	Cause of congestion (accident, construction work, flood and etc.)	64.0	36.0
4	Parking location in a certain area	61.5	38.5
5	Availability of parking	54.5	45.5
6	Estimated travel time to reach the destination	48.0	52.0

Table 4: Average Amount Private Vehicle Users were Willing to Pay for Traffic Information: Private Vehicle Users

Rank	Type Of Information	Average Amount Willing to Pay (RM*)
1	Seriousness of congestion (heavy, medium, light or no congestion)	0.29
2	Route guidance (info on alternative route or fastest route available)	0.26
3	Cause of congestion (accident, construction work, flood and etc.)	0.18
4	Parking location in a certain area	0.18
5	Availability of parking	0.15
6	Estimated travel time to reach the destination	0.14

* 1RM = US$0.2632.

Consistent with the ranking by importance, seriousness of congestion and route guidance information appeared to be the information for which drivers were willing to pay the highest amount. Note that this was only the amount that drivers were willing to pay for each piece of information before knowing which device would supply this information.

4.2.2 Type of Device Before Start of Trip

The third group of questions sought information regarding the preference among drivers on the type of device from which they would prefer to obtain the information (before the start of the trip). Table 5 shows the ranking of the preferences, whilst Table 6 presents the average points tabulation of the relative importance of the type of devices that supply information prior to starting a trip.

It can be seen from Table 5 that none of the methods by which this information could be supplied before the start of the trip was very popular. Only 38% of the road users considered the radio broadcasting as a "high preference", followed by telephone inquiry (16%), internet facilities (13%) and fax service (1%).

Table 5: Ranking of Information Before Start of Trip: Private Vehicle Users

	Type of Devices Before Start of Trip	High preference (%)	Average Preference (%)	Low Preference (%)
13	Radio broadcasting	38.0	46.5	15.5
14	Telephone inquiry where you can call and obtain traffic information	16.0	43.5	40.5
15	Fax service where you can request for latest traffic info using fax	1.0	11.5	87.5
16	Internet facilities where you have a website providing latest traffic information	13.0	34.5	52.5

Table 6: Average Points Tabulation of relative importance of Devices Prior to Start of Trip: Private Vehicle Users

Rank	Type of Device Before Start of Trip	Average Points	Preference Ranking
1	Radio broadcasting	3.440	Average Preference
2	Telephone inquiry where you can call and obtain traffic information	2.510	Average Preference
3	Internet facilities where you have a website providing latest traffic information	2.200	Average Preference
4	Fax service where you can request for latest traffic info using fax	1.260	Low Preference

4.2.3 Preference Among Drivers on Type of Device While Driving

The Group IV questions were about the devices that drivers preferred to receive information while they are driving. The preference ranking of the various devices and methods is provided in *Tables 7* and *8*.

Table 7: Ranking of Relative Preference of Various Methods While Driving: Private Vehicle Users

	Type of Device While Driving	High Preference (%)	Average Preference (%)	Low Preference (%)
17	Message signs placed along the road which continuously provide latest traffic information	74.0	25.0	1.0
18	An electronic board which shows the whole road network	73.5	22.5	4.0
19	A navigation system placed inside your car	45.0	45.0	10.0
20	Radio broadcasting	28.0	45.0	27.0
21	Roadside broadcasting (a particular frequency on the radio providing traffic information as you travel along a road)	19.0	46.0	35.0

It can be seen from *Table 7* that the most preferred devices for supplying information while driving were the variable message sign placed along the road (74%) and the electronic board (73.5%), with both rated as "high preference", followed by a navigation system inside the car (45%), radio broadcasting (28%) and roadside broadcasting (19%).

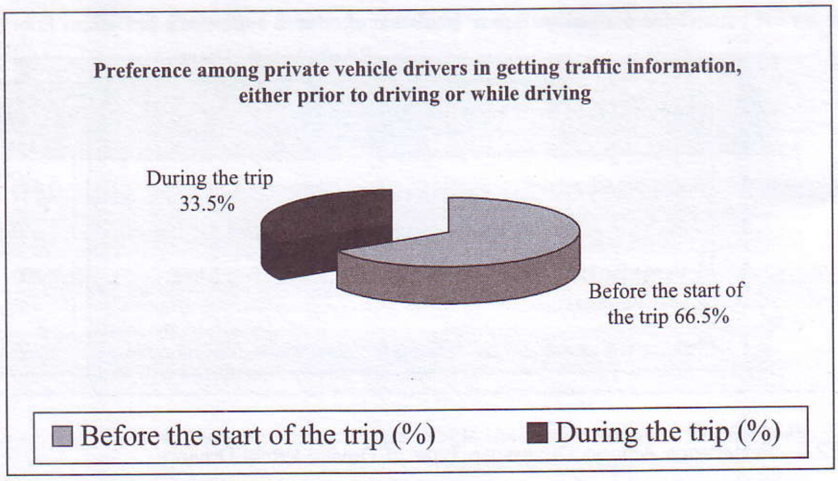
Table 8: Average Ranking of Devices While Driving: Private Vehicle Users

Rank	Type of Device While Driving	Average Points	Preference Ranking
1	Message signs placed along the road which continuously provide latest traffic information	4.445	High Preference
2	An electronic board which shows the whole road network	4.355	High Preference
3	A navigation system placed inside your car	3.665	Average Preference
4	Radio broadcasting	3.025	Average Preference
5	Roadside broadcasting (a particular frequency on the radio providing traffic information as you travel along a road)	2.605	Low Preference

Figure 1 compares the preference of private vehicle drivers in obtaining traffic information, whether while driving or prior to driving. It can be seen from the Figure that more than 65% of drivers preferred to obtain the traffic information prior to starting the trip.

Figure 1. Preferred method of obtaining traffic information

4.2.4 Discussion of Information Required for Private Vehicle Users



From the interviews of private vehicle users, it was found that the level of road congestion (heavy congestion, medium congestion, light congestion or no congestion) was the most important issue, with about 94% of the road users considering this information to be "very important". The willingness to pay and the average amount that drivers would pay for this information was about 84.5% and 29 cents respectively, which is between 1 or 2 times the unit price of a phone call in Malaysia (currently the charge rate per unit for a domestic call is RM0.13; or RM0.30 for a mobile phone call).

The second most important pieces of information were route guidance, cause of congestion and parking (parking location and availability), all of which were categorized as "important". The proportion of respondents who were willing to pay for this information ranged between 55% and 77% whilst the average amount that drivers were willing to pay for this information ranged between 15 cents and 26 cents per call. Information regarding the estimated travel time to reach a destination, or journey time, was categorized as "averagely important". The willingness to pay for this information was about 48% at a cost of about 14 cents.

It was also established from the surveys that, prior to driving, drivers prefer to obtain information from radio broadcasting. Telephone inquiries and Internet facilities had limited preference while only 1% favoured a fax service. This may be because radio broadcasting can be provided without additional charge and access to radio broadcasts is easy. Telephone services would require some form of payment, while Internet and fax facilities obviously require the driver to have ready access to a computer or a fax machine.

The most preferred device for supplying information while driving was variable message signs placed along the road, which continuously provide the latest traffic information. The second most preferred device was an electronic board, which shows the whole road network. These two devices were ranked as highly preferred due to the fact that no additional charges were incurred by the drivers.

A navigation system placed inside the car was chosen as an "average preference", while radio broadcasting and roadside broadcasting of traffic information on a particularly frequency was categorized as "low preference". This is probably because radio broadcasts are currently only provided at selected times and the information provided may not be relevant to the driver or his location/destination. The variable message sign, on the other hand, provides the latest site-specific information to drivers.

Finally, almost 66.5% of the drivers preferred to obtain their information at the start of the trip or before driving.

4.3 Public Transport Users

4.3.1 Importance of Different Items of Information

Public transport users were divided into four groups because various types of traffic information may have different significance to particular public transport users. Tables 9 and 10 present the results of the ranking of the relative importance, and average points, of the different types of information.

Table 9: Ranking of Relative Importance of Information: Public Transport Users

	Type Of Information	Very Important or Important (%)	Average Important (%)	Not Important (%)
1	Route information at bus – stops	79.0	19.5	1.5
2	Route information at terminals	78.5	20.0	1.5
3	Information on arrival times of buses and waiting times at bus stops	91.0	8.5	0.5
4	Information on arrival times of buses and waiting times at bus terminals	0.0	9.5	0.5
5	Integration of the operations between various modes of public transport	85.0	13.5	1.5
6	Integration in the ticketing system on all public transport	88.0	9.0	3.0

Table 10: Average Point Scores: Public Transport Users

Rank	Type Of Information	Willing to Pay (%)	Not Willing to Pay (%)
1	Information on arrival times of buses and waiting times at bus stops	4.915	Important
2	Information on arrival times of buses and waiting times at bus terminals	4.885	Important
3	Integration in the ticketing system on all public transport	4.610	Important
4	Integration of the operations between various modes of public transport	4.575	Important
5	Route information at bus stops	4.325	Important
6	Route information at terminals	4.305	Important

The majority of those interviewed considered the information on arrival times of buses and waiting times at bus stops and at terminals as the most important information that needs to be supplied. This was followed by the integration in the ticketing system and operation between various modes of all public transport users. Lastly is route information at bus stops and at terminals.

4.3.2 Willingness to Pay for Traffic Information

Table 11 presents information regarding public transport users willingness to pay for each type of traffic information and the average amount they were willing to pay for this information.

Table 11: Proportion of Respondents Willing to Pay and Average Amount for Information: Public Transport Users

	Willing to Pay (%)	Not Willing to Pay (%)	Average Amount Willing to Pay (RM)
Each Traffic Information	73.5	26.5	0.23

The average amount that public transport users were willing to pay for each type of traffic information was RM0.23.

4.3.3 Preferred Type of Device Before Start of Trip

The third group of questions concerned the preferred type of device which users would prefer to obtain the information (before the start of the trip). Table 12 provides a ranking of the preferences whilst Table 13 presents the level of preference for each device among public transport users.

Table 12: Ranking of Preference of Information Before Start of Trip: Public Transport Users

	Type of Device Before Start of Trip	High Preference (%)	Average Preference (%)	Low Preference (%)
8	Radio broadcasting	37.0	42.5	20.5
9	Telephone inquiry where you can call and obtain traffic information	18.5	42.5	39.0
10	Fax service where you can request for latest traffic info using fax	3.0	12.5	84.5
11	Internet facilities where you have a website providing latest traffic information	13.0	38.5	48.5

Table 13: Average Points Tabulation of Relative Importance of Type of Device: Public Transport Users

Rank	Type of Device Before Start of Trip	Average Points	Preference Ranking
1	Radio broadcasting	3.320	Average Preference
2	Telephone inquiry where you can call and obtain traffic information	2.600	Average Preference
3	Internet facilities where you have a website providing latest traffic information	2.290	Average Preference
4	Fax service where you can request for latest traffic info using fax	1.380	Low Preference

From *Table 12* it can be seen that the most preferred methods for receiving information before the start of the trip was radio broadcasting (37%), followed by telephone inquiry 18.5%, Internet facilities (13%) and fax service (3%).

4.3.4 Preference on the Type of Devices While They Are Travelling

The Group IV questions concerned those devices preferred to provide information to public transport users while they are travelling. The ranking of the various devices and methods are provided in Tables 14 and 15.

It can be seen from Table 14 that the most preferred device for supplying information while travelling was an electronic board display at a bus-stop, which at 69.5% was considered to be of "high preference", followed by changeable message signs at the terminal (67.5%). Exclusive traffic information station (roadside broadcasting) (24.5%) and Internet facilities 15% were only of "average preference" while telephone inquiry (9%) and fax services (1.5%l were of "low preference".

Table 14: Ranking of Relative Preference of Methods of Supplying Information While Travelling: Public Transport Users

	Type of Device While Travelling	High Preference (%)	Average Preference (%)	Low Preference (%)
12	Changeable message sign at the terminal	67.5	29.0	3.5
13	Electronic board display at bus – stops	69.5	28.5	2.0
14	Exclusive traffic information station (Roadside broadcasting)	24.5	36.5	39.0
15	Internet facilities	15.0	31.0	53.5
16	Automatic telephone inquiry	9.0	45.0	46.0
17	Fax services	1.5	9.0	89.5

Table 15: Average Points of Preference Ranking of Different Devices While Travelling

Rank	Type of Device While they are Travelling	Average Points	Preference Ranking
1	Electronic board display at bus – stops	4.350	High Preference
2	Changeable message sign at the terminal	4.280	High Preference
3	Exclusive traffic information station (Roadside broadcasting)	2.720	Low Preference
4	Automatic telephone inquiry	2.260	Low Preference
5	Internet facilities	2.240	Low Preference
6	Fax services	1.240	Low Preference

From *Figure 2* it can be seen that 59% of public transport users preferred to obtain their traffic information prior to starting the trip.

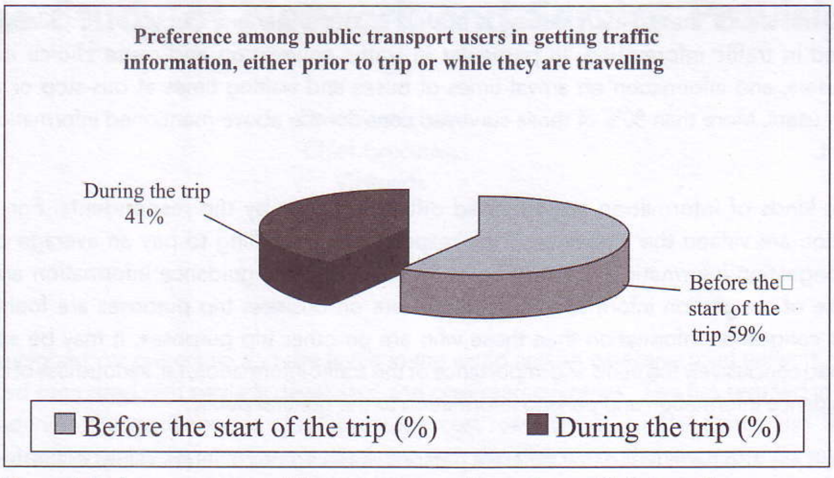


Figure 2. Preference among public transport users in getting traffic information

4.3.5 Discussion of Information Required For Public Transport Users

From the survey of public transport users, it was found that the most popular type of information which was required was the arrival time of the public transport and anticipated waiting times at bus stops and terminals. Other types of information were the integration of operations between various modes of public transport and integration of the ticketing system so that it covered all forms of public transport,; these were ranked as "important". Information on bus routes was also ranked as "important". The most valuable information for public transport users was the arrival time, waiting period and departure time of the public transport network.

The proportion for respondents who were willing to pay for the various types of traffic information was about 73.5% and the average amount was 23 cents. The most preferred facility for supplying traffic information to public transport users before the start of the trip was radio broadcasting. This may be because this facility would not involve extra costs and was easily accessible. Telephone inquiries and internet facilities were not highly preferred while the fax service was of "low preference".

The most preferred method of receiving information whilst travelling were electronic board displays at bus stops and variable message signs at terminals ("high preference"), followed by roadside broadcasting, telephone inquiry and Internet facilities ("average preference"). A fax service placed in the terminal was ranked as "low preference". Similarly to drivers, public transport users preferred facilities that did not involve extra charges and were easily accessible. However, as just noted, public transport users were willing to pay an extra cost of about 23 cents if this information was furnished.

Finally, the survey of the public transport users highlighted the fact that the most public transport users preferred to obtain information prior to starting their trip.

6. CONCLUSIONS

This paper has described a study conducted in Malaysia which involved the evaluation of various intelligent transport integrated systems (ITIS) and the willingness of both private vehicle users and public transport users to pay for this information.

The introduction of an integrated traffic information system in Klang Valley Area can be expected to produce significant benefits. Among them, time saving brought about by the efficient use of the existing road network will be the biggest benefit. Other benefits include improved traffic safety, reduced adverse environmental impacts by traffic, and enhanced comfort and reliability in vehicular travel. Like many other information related systems, benefits of these integrated traffic information systems are wide ranging in nature including many indirect benefits. Moreover, many of these benefits, both direct and indirect are in fact difficult to quantify. Improved overall traffic safety, improved travel comfort, better confidence among road users are some examples of indirect benefits that are indeed very difficult to quantify. Not only the road users and road administrators will benefit from the proposed system, but the general public will benefit from it as well.

From the results of the opinion survey, it is clear that the general public in the Klang Valley Area are very interested in traffic information, in particular in traffic congestion and route choice information for private vehicle users, and information on arrival times of buses and waiting times at bus-stop or at terminals for public transport users. More than 80% of those surveyed consider the above-mentioned information as important or very important.

Different kinds of information are attached different values by the respondents. For example, congestion information are valued the highest and the respondents are willing to pay an average of RM0.29 per item of traffic congestion information, an average of RM0.26 for route guidance information and RM0.18 for parking and cause of congestion information. Those who are on business trip purposes are found to be willing to pay more for congestion information than those who are on other trip purposes. It may be said that the survey has established conclusively the need and importance of this traffic information, i.e. seriousness of congestion information, route guidance information and parking information to the general public.

However, it has also been found that different persons would accord different values to these different items of traffic information. There are a substantial number of people who have accorded enough importance to this traffic information to be willing to pay for this information.

Private vehicle users prefer to obtain this information prior to starting the journey rather than while travelling. The types of devices preferred include radio broadcasting and telephone inquiry are devices chose to obtain information before driving. In terms of receiving information while driving, driver prefer to obtain information via variable message signs along the road and electronic boards.

Public transport users consider information on arrival time of buses and waiting time at bus stops and terminals as the most important type of information. On the average, they are willing to pay an additional in the fare for this information. Public transport users prefer to obtain this information prior to starting the trip rather than while travelling. The types of devices preferred include radio broadcasting and telephone inquiry similar to private vehicle. In terms of receiving information while travelling, the public transport users prefer to obtain information via electronic boards and changeable message signs at terminals.

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A Case Study of Network and Service Provision

David Anderson
Chief Executive
VicRoads

ABSTRACT

Australia has one of the highest car ownership and use levels in the world and an extensive road network. The network is generally lightly trafficked compared with similarly developed and governed countries. This has resulted in Australian road agencies becoming leaders in the management of relatively low cost road networks. The States and Territories adopt varying approaches to obtaining value for money, in accordance with the policies of the respective Governments.

This paper presents details of the operation of an Australian State Road Agency (VicRoads) and the steps that it has taken to provide convenient and cost-effective services to its customers. Emphasis over the next 18 months will be on creating a customer service culture, enhancing staff skills in dealing with customers and establishing reporting processes to further drive business improvement in customer service.

1. INTRODUCTION

Australia has a relatively small population of around 20 million occupying a very large land mass of 7.688 million square kilometres (or about 90% of the size of mainland USA). Eighty-three per cent of the population lives in urban areas and sixty-four per cent of the population lives in State/Territory capital cities, with thirty-nine per cent of people living in just two cities – Sydney and Melbourne. Much of the centre of Australia is very sparsely populated.

Australia has a Federal system of Government with a national government, six State and two mainland territory governments. Local Governments are established under State legislation.

Australia has one of the highest car ownership and use levels in the world and an extensive road network (812,000 km of roads, including 18,600 km of National Highway, 107,000 km of State roads and 686,000 km of Local Roads). The network is generally lightly trafficked compared with similarly developed and governed countries. This has resulted in Australian road agencies becoming leaders in the management of relatively low cost road networks. The States and Territories adopt varying approaches to obtaining value for money, in accordance with the policies of the respective Governments.

Victoria is Australia's second smallest State by area, but is the second most populous, after New South Wales. Over seventy-two per cent of Victoria's population lives in its capital city, Melbourne. There are 22,250 km of arterial roads in the State and, of the 36,700 million vehicle-km travelled each year, sixty per cent of vehicle travel is in Melbourne. One-quarter of all Australian vehicles are in Victoria (3.5 million motorists, 3.8 million vehicles), and one-quarter of Australian road freight is moved in Victoria.

2. ROAD FUNDING AND MANAGEMENT

The Federal Government has sole financial responsibility for funding the construction and maintenance of the National Highway system. It funds construction works on defined "Roads of National Importance" jointly with the States. The Federal Government also funds approved road safety improvements (Blackspots) and provides untied funds to Local Government authorities. Local Government is free to expend these untied funds on roads or other priorities of Local Government. The Federal Government does not have direct road management responsibility.

State and Territory Government road transport and traffic agencies are responsible for the development, maintenance, operation and management of the principal road network within their area of jurisdiction. Typically, State and Territory Governments are responsible for the funding of State Highways, and are either fully responsible for, or share with local government, funding for State arterial roads.

Australia spends about $6.5 billion annually on enhancing and maintaining the road network. Road authorities must manage the system and road investment dollars effectively in order to provide for community needs and to support national economic development.

3. VICROADS

VicRoads is the registered business name of the Victorian Roads Corporation – the State road authority. Established as a Corporation under the *Transport Act*, VicRoads serves the community by managing the Victorian road system and its use as an integral part of the overall transport system. As part of the Government's Infrastructure Portfolio, VicRoads also has a key role in advising the Minister for Transport and implementing Government policies and strategies.

VicRoads aims are to:

- achieve ongoing reductions in the number and severity of road crashes and the resultant cost of road trauma;
- assist economic and regional development by managing and improving the effectiveness and efficiency of the road transport system;
- facilitate greater integration of road based public transport with other transport modes to maximise choice, accessibility, safety and reliability for all road users;
- minimise the impact of roads and traffic on the community and enhance the environment through responsible planning and management of the transport system; and
- build effective, equitable and efficient relationships with all customers by providing them with convenient access to services that meet their needs and enable VicRoads to deliver cost effective services to the community.

3.1 Operating Arrangements

VicRoads is structured around five Divisions

- Regional Services: five rural regions and two metropolitan regions that are responsible for identifying local needs and managing the delivery of the full range of regionally based services determined for each core business program (road system management, registration and licensing, traffic and transport integration, and road safety).
- Major Project teams with specialist communications staff, and project and contract management skills, are established as and when required to deliver major infrastructure projects. Major Projects also provides project planning, development and environmental services.
- Commercial Services provides services that support the core businesses, regions and major project teams such as technical, information and engineering services, generally on a commercial basis.
- The Organisation Support Division provides corporate services that support the management of the organisation as a whole.
- Business Operations includes the core business departments as well as the Finance, Human Resources, and Chief Information Officer Departments.

The organisation has a total staff of approximately 2,300.

4. SERVING THE CUSTOMER

In the broadest sense, VicRoads' customers include 4.8 million Victorians as well as interstate and international visitors who use the road network.

As mentioned above, VicRoads has four core businesses which provide a clear focus for the delivery of its services:

- Road System Management
- Registration and Licensing
- Traffic & Transport Integration
- Road Safety

4.1 Road System Management

The Road System Management program focuses on maintaining and improving Victoria's road assets. The program directs:

- the application of appropriate cost effective treatments to improve road quality;
- the development, monitoring and review of asset management strategies to improve road system performance – these strategies address highway management (including national highways) and maintenance management (bridges, pavements and the roadside); and
- major additions to the road system.

The new *Road Management Act* will see significant change to road management practices in Victoria by delivering improved rights for road users, better road management, more consistent road standards and a more efficient and safer road network.

4.2 Registration and Licensing

The Registration and Licensing Program aims to provide equitable, cost effective and accessible services to the community.

Products and services including vehicle registration and driver licensing and information services, are provided through a range of service channels including: regional customer service centres, post offices, banks, municipal offices, new car dealers, the internet, and call centres.

Performance standards such as maximum waiting times are set for each delivery channel. Performance is measured against these standards and through mystery shopper research and a bi-annual customer satisfaction survey.

4.3 Traffic & Transport Integration

The Traffic and Transport Integration Program is driven by strategies such as the draft Victorian Freight and Logistics Strategy and the Metropolitan Road and Traffic Management Strategy. The Program aims to deliver safe, efficient and orderly movement of road users and road freight by:

- reducing traffic congestion and traffic delays and minimising the impact of incidents on traffic flow;
- improving travel time and reducing travel time variability for freight and road based public transport;
- extending the arterial bicycle network;
- enhancing the movement and equality of road access for pedestrians;
- improving information and advice to road users; and
- traffic system performance monitoring.

These programs and strategies are developed and implemented in consultation with stakeholders through Advisory Councils and Forums including freight, bicycles, motorcycles, road-based public transport, and ports area operations

4.4 Road Safety

VicRoads is responsible for the delivery of the State Government's road safety strategy, *arrive alive!*, which aims to achieve a sustainable reduction in the number and severity of road crashes and the cost of road trauma. The strategy drives the road safety program which focuses on initiatives for:

- safer roads – roads and roadsides;
- safer vehicles – roadworthiness, modified, special and heavy vehicles, occupant protection, vehicle information; and
- safer road users – speed management, drink driving, drugs and driving, motorcycle programs, fatigue programs, and road safety education.

The development and delivery of the road safety programs is a collaborative effort which involves VicRoads working closely with other government departments, local government, local community groups and other key stakeholders.

4.5 Other Services

In addition to the program direction of the four core businesses, VicRoads also has a number of corporate-wide initiatives which aim to build relationships with its customers. The most significant of these include:

- The VicRoads Advisory Board, which is the prime mechanism by which VicRoads "involves road users in management."
- Community Participation Strategies and Guidelines which assist VicRoads' staff in designing and implementing strategies for community participation in road planning, road construction and road improvement activities.
- The corporate correspondence system, which manages correspondence received by the Minister for Transport and the Chief Executive.

5. DOING BUSINESS BETTER

VicRoads has identified a number of priorities for attention to enable it to deliver better services to the community and government.

In general terms, VicRoads has focused its improvement activities on the following key areas:

- Listening to the community – responding effectively to community needs by better understanding different points of view and different community values.
- Working with others – other Government departments and agencies, local government and key stakeholders to achieve the Government's desired outcomes.
- Getting things done – better managing forward planning and project delivery including more effective community consultation.
- Developing capabilities – knowledge, expertise and skills.

Specific actions include:

- The development of a comprehensive Customer Service Strategy to ensure the efficient delivery of VicRoads' services to its customers. The focus of the strategy is on creating a customer service culture, enhancing staff skills in dealing with customers and establishing reporting processes to drive business improvement in customer service.
- The establishment of a Customer Enquiry Tracking System to better identify, understand and respond to emerging community and stakeholder issues at a regional and corporate level.
- The development of a Corporate Intranet (launched in March 2004) to ensure that staff have the information they need in a timely manner.
- Review of the Community Participation Strategies and Guidelines to ensure the effectiveness of existing processes for consultation with community groups and stakeholders.
- Training in listening skills and problem solving and responding effectively to the community.
- Strengthening of relationships with local government and regional groups as key sources of community issues and information.

This will enable VicRoads to ensure that:

- business processes are based on the customer's perspective rather than the organisation's view of the world;
- customer service delivery channels are integrated and transactions are consistent across channels; and
- consistent and accurate information and outcomes are delivered to customers.

6. CONCLUDING COMMENTS

This paper has presented details of the operation of an Australian State Road Agency (VicRoads) and the steps that it has taken to provide convenient and cost-effective services to its customers. Emphasis over the next 18 months will be on creating a customer service culture, enhancing staff skills in dealing with customers and establishing reporting processes to further drive business improvement in customer service.

Accelerated Pavement Testing in Korea

Young Chan Suh
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Hee Mun Park
Korea Institute of Construction Technology

Studies of the relationships between traffic loading and pavement performance have been conducted by many researchers throughout the world. Research areas include computer simulation, laboratory and insitu testing, accelerated pavement testing (APT), and field trials of in-service pavements. The aims of these approaches are to calibrate and verify pavement design guides, and evaluate the application of new pavement materials through the accurate prediction of pavement performance. APT is an efficient way of assessing and predicting pavement performance.

The Hanyang University Accelerated Pavement Tester (HAPT) is the first full-scale accelerated pavement tester developed in Korea and it has already been successfully used in various research projects. The HAPT offers opportunities to verify the newly-developed Korean Pavement Design Guide and evaluate the performance of pavement materials produced in Korea.

The HAPT traffics a test pavement 12.5 m long at a speed of up to 17 km/h and a maximum wheel load of 11.2 tonne (11 ton). The load can be applied over a lateral distribution to simulate normal traffic and a pavement heating system allows the effects of pavement temperature to be examined. General views of the HAPT are shown in *Figures 1-3*.

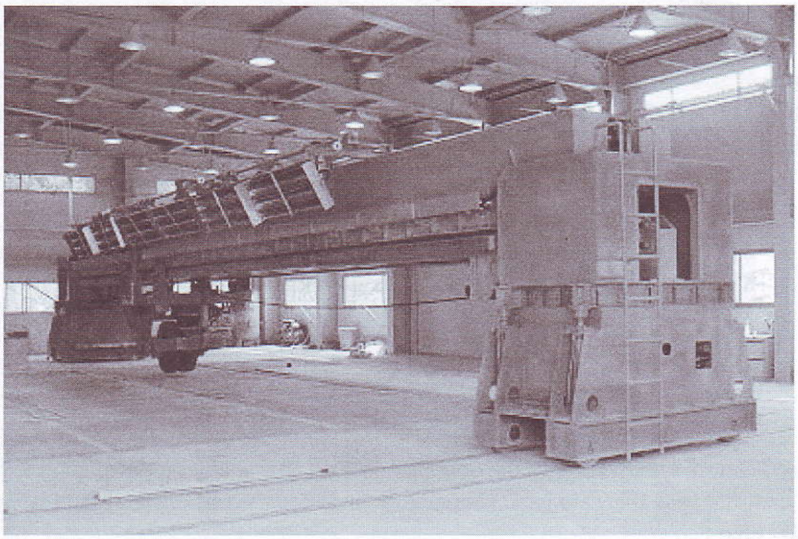


Figure 1: General view of HAPT

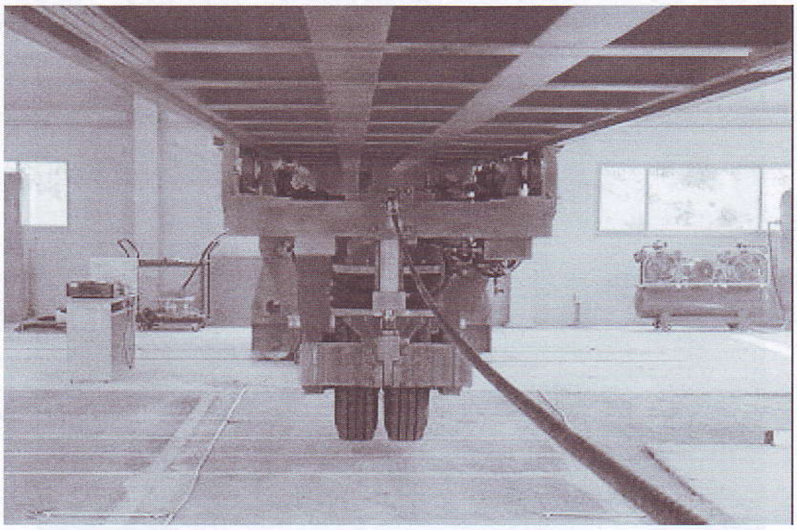


Figure 2: View of dual wheel assembly

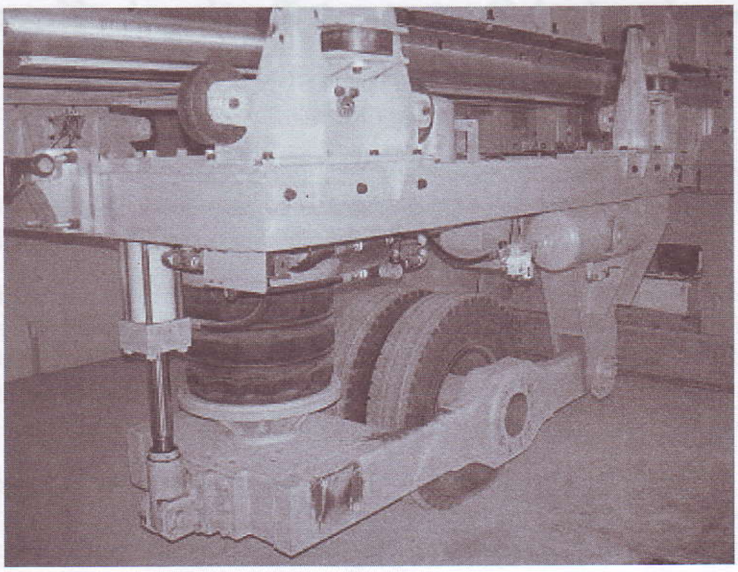


Figure 3: View of suspension system

The facility is located at Hanyang University in Korea. General details of the facility are given in *Table 1*. The testing site consists of three linear test tracks, each 12.5 m long and 9.3 m wide.

Table 1: General Details of Test Facility

Content	Description
Area	24 m x 28 m, 700m^3
Height	center: 7.7 m, side: 6m
Main Entrance	length: 7.5m, height: 4m
Exit	length: 4.5m, height: 4m area: 12.5x9.3m, depth: 3m
Test Pit	subgrade: sand, depth: 2 m Base: unbound material, Depth: random
Others	Control and Apparatus room, toilet, and warehouse

The instrumentation and control system controls the operation, collect all the information relating to the operation (speed, location, load level), and manages the data (e.g. temperature and strain/stress). This system is designed to store and analyse the data in real time.

The pavement heating system was developed to allow the effects of pavement temperature to be examined. The system is installed on top of the girder and uses infrared ray to increase pavement temperature. A temperature gauge system is used to automatically maintain the desirable temperature. Photos of the system are shown in *Figures 4* and *5*.

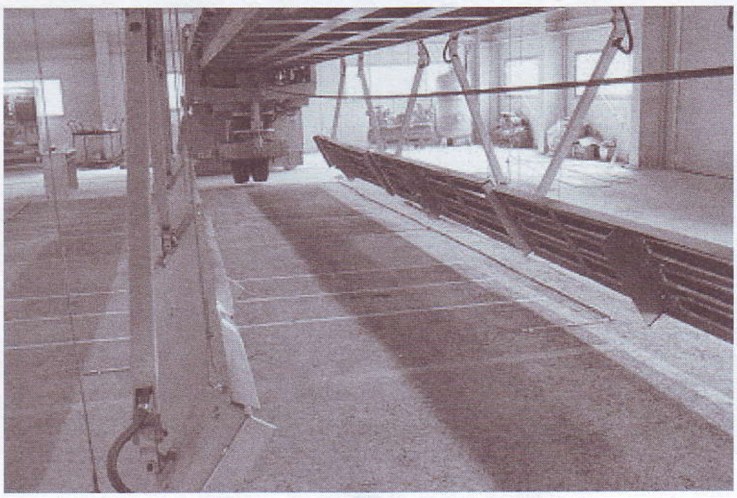


Figure 4. View of pavement heating system from level of pavement

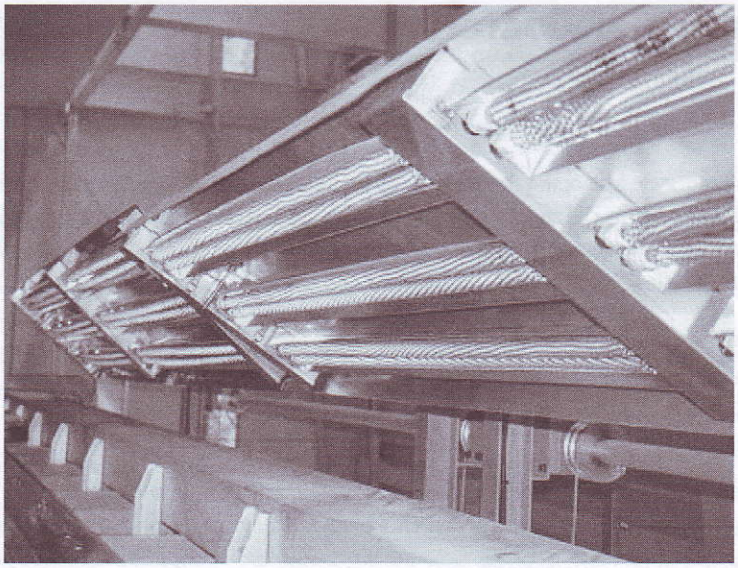


Figure 5. View of pavement heating system

Instrumentation used includes strain gauges for measuring pavement response in all layers, longitudinal and transverse laser profilometry for measuring pavement performance, and thermocouples for measuring pavement temperature. In the future, it is planned to adopt an Automated Road Image Analyzer (ARIA) system to provide more accurate performance data.

Research conducted by the Korea Institute of Construction Technology (KICT) and Hanyang University to date using the HAPT has included the performance of dense-graded and modified asphalt. The next project will involve the performance of long life pavements. Future projects will include the long-term performance of newly-developed materials and the verification and calibration of the Korean Pavement Design Guide.

6th International Conference on Managing Pavements

"The Lessons; The Challenges, The Way Ahead"

The 6th International Conference on Managing Pavements will be held from 19-24 October 2004 at the Brisbane Convention & Exhibition Centre, Brisbane, Australia. The International Pavement Management Conferences held over the last ten years have recognised in their themes the importance of institutional issues and sustainability, as well as the importance of innovation in technical capabilities and practices.

The technical program is based around the following six themes:

1. Communicating the road asset management message
2. Performance achieved with improved practices
3. Outcomes, benefits, impacts and risks
4. Integrating pavement management systems and road asset management in organisations
5. Innovation in practices and technologies
6. Sustaining good practice in our organisations

Over 100 papers will be presented by authors from Australia, New Zealand, South-East Asia, North America, South Africa and Europe. A highlight of the technical program will be keynote addresses presented at the start of each day's activities. The keynote speakers are:

King W. Gee, Federal Highway Administration, USA
Anil Bhandari, The World Bank Group, USA
Louw Kannemeyer, African National Roads Agency Group, South Africa
Lindsay Crossen, Fulton Hogan Ltd, New Zealand
Steven Golding, Queensland Department of Main Roads, Australia
Charles Melhuish, Asian Development Bank, Philippines

Pre-Conference Workshops

The program on Tuesday 19th and Wednesday 20th October involves the following pre-Conference Workshops of either half-day or full-day duration.

PW1: Queensland Roads Alliance: Road and Bridge Asset Management Initiative

Arranged by: Queensland Department of Main Roads and the Local Government Association of Queensland

This Workshop will examine an innovative inter-government arrangement that will jointly plan for, program and deliver works on regional road networks comprising both local and State-controlled roads. The collaborative partnership is seen as a model within Australia, and will interest road asset managers from all countries for which road network stewardship is the responsibility of all levels of government.

PW2: HDM-4 – Recent Developments and Applications

Arranged by: ARRB Transport Research

This Workshop will present case studies for applications of HDM-4 technology, and will demonstrate the range of enhanced capabilities of HDM-4 Version 2. The Workshop will be of interest to existing HDM-4 users, and those wishing to understand the potential for HDM-4 to give more informed insight into the life cycle performance of road investments.

PW3: Infrastructure Protection Standards for Heavy Vehicles

Arranged by: ARRB Transport Research and the National Transport Commission

This Workshop will discuss future challenges for Australian road sector jurisdictions. The issues are not unique to that region, and delegates from other countries will find many similarities with their own experiences. The Workshop will examine issues concerning the impacts of heavy vehicles on the ageing infrastructure, and the evolving regulatory processes for containing the asset impact of new freight vehicle technologies through performance-based vehicle standards.

PW4: Developments in Road Condition Data Collection

Arranged by: Austroads Assets Task Force

This purpose of this Workshop is to examine recent developments in, and applications for, the technologies for vehicle-based automated data collection, including the measurement of surface cracking and skid resistance, and the use of digital

road images as an asset management tool. Recent Austroads work to develop guidelines for road condition data collection (pavement roughness, rutting, strength and skid resistance) will also be discussed. Opportunities will be available for presentations on the topic from international delegates.

PW5: Introduction to Road Asset Management

Arranged by: TRB Pavement Management Systems Committee

This full-day workshop is based on an introductory course, offered by the U.S. National Highway Institute, which covers the principles, concepts, components, techniques, and benefits of Asset Management. The course illustrates asset management "best practices" in key functions of a transportation agency's resource allocation and utilisation: policy development, planning and programming, program delivery, operations, and use of information and analytic tools. It also provides a self-assessment process that can be applied within transportation agencies to benchmark current asset management practices and identify potential areas for further enhancement and implementation.

Pavement Management Investment Analysis Challenge

In the "*ICMP6 Pavement Management Investment Analysis Challenge*", the great diversity of pavement management practices and technologies used throughout the world will be applied to a common investment problem – that of developing a maintenance investment program for a defined road network with a defined maintenance budget limit. The Challenge provides a unique opportunity to learn about and disseminate good practice in methodologies for investment analysis. Teams from the United Kingdom, New Zealand, South Africa, North America and across Australia have expressed interest in participating in the Challenge. The Challenge will be supported by poster displays which will allow delegates to have more detailed discussions with the participants.

Trade Displays, Technical Tours and Social Program

A large number of trade displays will be presented. Optional technical tours will be held on 18th and 19th October and a series of social functions – including an Accompanying Persons program – will be held throughout the week.

Registration

Full details of the Conference, including details of block-booked accommodation and a registration form, are available on: www.icmp6.com.

Forthcoming Conferences

UNBAR 6: 6th International Symposium on Unbound Pavements
Date: 6-8 July 2004; Nottingham, United Kingdom
Organized by Nottingham Centre for Pavement Engineering
Contact: Marzena Newton,
UNBAR 6, Nottingham Centre for Pavement Engineering,
School of Civil Engineering, University of Nottingham,
University Park, Nottingham NG7 2RD, UK
Tel: +44-115-846-6046; Fax: +44-115-951-3090
Email: marzena.newton@nottingham.ac.uk
Website: http://www.nottingham.ac.uk/u6/

ICTTS'2004: 4th International Conference on Traffic and Transportation Studies
Date: 2-4 August 2004; Dalian, People's Republic of China
Contact: Local Organizing Committee/ICTTS
(Prof. Mao, Baohua),
School of Traffic and Transportation,
Northern Jiaotong University, Beijing 100044, PRC
Tel: +8610-5168-8695; Fax: +8610-5168-8308
Email: ictts04@center.njtu.edu.cn

3rd CECAR: Third Civil Engineering Conference in the Asian Region
Date: 16-19 August 2004; Seoul, Korea
Organized by Asian Civil Engineering Coordinating Council (ACECC)
Contact: ACECC
Website: http://www.3rdcecar.com

Symposium on Mechanics of Asphalt Concrete:
Sixth World Congress on Computational Mechanics
Date: 5-10 September 2004; Beijing, China
Contact: Ms Yanan Tang,
Chinese Society of Theoretical and Applied Mechanics,
No 15, Bei-Si-Huan-Xi Road, Beijing 100080, PRC
Tel: +86-10-62559588; Fax: +86-10-62559588
Email: registration@wccm6-apcom04.org.cn
Website: http://www.wccm6-apcom04.org.cn

7th Australian Injury Prevention Conference,
and 2nd Pacific Rim Safe Communities Conference
Date: 15-17 September 2004; Mackay, Queensland
Organized by Australian Injury Prevention Network (AIPN)
Contact: Maria Lamari,
Australian Injury Prevention Conference,PO Box 3379, Norman Park Qld 4170, Australia
Tel: +61-7-3847-2055; Fax: +61-7-3847-2148
Email: conference2004@aipn.com.au
Website: http://www.aipn.com.au/conference

CityTrans China 2004
Date: 17-19 November 2004; Shanghai, China
Organized by National University of Singapore,
and Tongji University, China
Contact: MP Asia Pte Ltd
Tel: +65-6297-2822; Fax: +65-6296-2670
Email: info@citytranschina.com
Website: http://www.citytranschina.com

Symposium on Segmental Construction in Concrete
Date: 26-29 November 2004; New Delhi, India
Organized by The Institution of Engineers (India)
Contact: Hon. Secretary, O.C. fib Symposium 2004
Tel: +91-11-2627-2448; Fax: +91-11-2627-2447
Email: fib2004@rediffmail.com
Website: http://www.rediffmail.com

84th Annual Meeting of the Transportation Research Board
Date: 9-13 January 2005; Washington, DC, USA
Organized by Transportation Research Board (TRB)
Contact: Linda Karson,
Transportation Research Board, The National Academies,
500 Fifth Street, NW, Washington, DC 20001, USA
Tel: +1-202-334-2362; Fax: +1-202-334-2920
Email: lkarson@nas.edu
Website: http://www4.nationalacademies.org/trb/

IRF 2005: 15th World Meeting of the International Road Federation (IRF)
Date: 16-20 June 2005; Bangkok, Thailand
Organized by International Road Federation (IRF)
Contact: Conference Secretariat IRF 2005,
RAI Group, 226/36-37 Bond Street, Riviera Tower 1,
Muang Thong Thani, Bangpood,
Pakkred, Nonthaburi 11120, Thailand
Tel: +662-9600141-3; Fax: +662-9600140
Email: irf2005@bkkrai.com

7th International Conference on the
Bearing Capacity of Roads, Railways and Airfields
Date: 27-29 June 2005; Trondheim, Norway
Organized by Norwegian University of Science and Technology (NTNU)
Contact: Conference Secretariat,
NTNU videre, Pavilion A, Dragvoll, NO-7491 Trondheim, Norway
Tel: +47-73595254; Fax: +47-73595150
Email: bcra2005@adm.ntnu.no
Website: http://www.bcra05.no

2nd International Conference on Accelerated Pavement Testing
Date: 19-22 September 2004; Minneapolis, Minnesota
Organized by Transportation Research Board (TRB)
Contact: Stephen Maher,
Transportation Research Board (TRB),
500 Fifth Street, NW, Washington, DC 20001, USA
Email: smaher@nas.edu
Website: http://gulliver.trb.org/conferences/2004-APT_Conf.pdf

ETC 2004: European Transport Conference
Date: 4-6 October 2004; Strasbourg, France
Organized by Association for European Transport
Contact: Sally Scarlett, Manager, AET,
1 Vernon Mews, Vernon Street, London W14 0RL, UK
Tel: +44-20-7348-1978; Fax: +44-20-7348-1989
Email: info@aetransport.co.uk
Website: http://www.aetransport.co.uk

IABMAS'04: Second International Conference on Bridge Maintenance, Safety and Management
Date: 19-22 October 2004; Kyoto, Japan
Organized by International Association of Bridge Maintenance and Safety (IABMAS)
Contact: Tomoaki Utsunomiya, IABMAS'04 Secretariat, Department of Civil and Earth Resources Engineering, Kyoto University, Kyoto 606-8501, Japan
Tel: +81-75-753-5078; Fax: +81-75-753-5130
Email: iabmas04@str.kuciv.kyoto-u.ac.jp
Website: http://iabmas04.kuciv.kyoto-u.ac.jp

6th International Conference on Managing Pavements: the Lessons, the Challenges,the Way Ahead
Date: 19-24 October 2004; Brisbane, Australia
Organized by Queensland Department of Main Roads and US Transportation Research Board
Contact: OzAccom Conference Services
PO Box 164, Fortitude Valley Qld 4006, Australia
Tel: +61-7-3854-1611; Fax: +61-7-3854-1507
Email: icmp6@ozaccom.com.au
Website: http://www.icmp6.com/icmp6/contact.htm

ISAET '04: 3rd International Symposium on Asphalt Emulsion Technology: Manufacturing, Application and Performance
Date: 28-31 October 2004; Washington, DC, USA
Organized by Asphalt Emulsion Manufacturers Association (AEMA)
Contact: ISAET '04, Asphalt Emulsion Manufacturers Association, #3 Church Circle - PMB 250, Annapolis, MD 21401, USA
Tel: +1-410-267-0023; Fax: +1-410-267-7546
Email: krissoff@aema.org
Website: http://www.aema.org

ConMat'05 Third International Conference on Construction Materials: Performance, Innovations and Structural Implications
Date: 22-24 August 2005; Vancouver, Canada
Organized by University of British Columbia (UBC)
Contact: Secretariat: Ms Terry Moser, Civil Eng. Dept., The University of British Columbia, 2010-2324 Main Mall, Vancouver, BC, Canada, V6T 1Z4
Tel: +1-604-822-5984; Fax: +1-604-822-6901
Email: tmoser@civil.ubc.ca
Website: http://www.civil.ubc.ca/conmat05

Sustainable Planning 2005: Second International Conference on Sustainable Planning and Development
Date: 12-14 September 2005; Bologna, Italy
Organized by Wessex Institute of Technology
Contact: Katie Banham, Conference Secretariat, Sustainable Planning 2005, Wessex Institute of Technology, Ashurst Lodge, Ashurst, Southampton, SO40 7AA, United Kingdom
Tel: +44-238-029-3223; Fax: +44-238-029-2853
Email: kbanham@wessex.ac.uk
Website: http://www.wessex.ac.uk/conferences/2005/index.html

ISAP Quebec 2006: 10th International Conferenceon Asphalt Pavements
Date: 12-17 August 2006; Quebec, Canada
Organized by International Society for Asphalt Pavements (ISAP)
Contact: International Society for Asphalt Pavements, 4711 Clark Avenue, Suite G, White Bear Lake, MN, USA 55110
Tel: +1-651-222-1128; Fax: +1-651-293-9193
Website: http://www.icap2006.fsg.ulaval.ca/english/english.htm

News Items

"THE REAAA MINO ROADSHOW" PROPOSED

One of REAAA's objectives under its strategic plan is to assist the professional development of members through technology transfer.

During 2001, a successful 3-day Seminar was conducted in Bangkok which explored emerging issues and challenges for managers of the regions' road networks. This Seminar was funded in large part by the Asian Development Bank (ADB) but with support from the World Bank and a small number of REAAA institutional members such as ARRB Transport Research and Transit New Zealand.

At the 2nd Heads of Road Authorities (HORA) Meeting, held in Cairns, Queensland, in May 2003, there was considerable support for REAAA to develop an active technology transfer program to update skills and to keep abreast of changes and improvements in technology. Subsequently the New Zealand and Australian Chapters respectively have identified training needs of countries in the Pacific region and existing training providers, documenting the courses provided. This information has informed the development of the proposed REAAA Mino Roadshow.

At the REAAA Council meeting held in Hanoi in October 2003, agreement was reached to fully develop a proposal for a Roadshow to be initially implemented in Pacific Island nations, such as Samoa, Fiji, and Tonga. The meeting also decided to adopt the name REAAA MINO ROADSHOW in memory of former President and long-serving member of the Governing Council, Dr Sadamu Mino.

Based on research, supported by the REAAA Council members own experiences there is a pressing need in the less developed countries for professional development in various aspects of road management, especially asset management and road safety

The rationale behind the Roadshow is that it is far more cost effective to take information training and technology transfer to the recipients. In addition, technology can be transferred within a locally relevant and practical context. The professional development technical content will be pitched at a level that is appropriate for the local audience, recognising that managers, engineers and technicians are likely to attend the Workshops, from both Government and commercial organisations.

The objective of the REAAA Mino Roadshow is to ensure that the relevant road practitioners are informed using 'face to face' contact methods with the Roadshow presenters. The objectives include:

- update road practitioners on current best practice principles;
- provide them with an appreciation of the relevant operational principles applicable to practice; and
- adopt relevant practices to meet unique country needs.

Currently REAAA Council members have undertaken to confirm sources of funding prior to committing to the implementation of the REAAA Mino Roadshow.

TECHNICAL PAPER COMPETITION 2004

The REAAA New Zealand Chapter promotes a technical paper competition each year to encourage members to prepare papers that would be suitable for publishing in the NZ Chapter Newsletter, the REAAA Journal and could also be presented at events such as the REAAA NZ Chapter Road Show.

There are two categories open for submission: papers on 'innovation', and papers on 'the practical application of research'.

A prize of up to NZ$3,000 is awarded to the best paper in each category, which goes toward travel and attendance expenses at a Conference. A condition of entry must be that papers can be published in either the REAAA NZ Chapter Newsletter or the REAAA Journal.

The review panel for the 2003 Technical Paper Competition was very pleased with the quality of papers received, although this year no award was given under the 'innovation' category.

The award for papers on 'the practical application of research' was given to Dr Bryan Pidwerbesky, Group Technical Manager, Fulton Hogan Ltd and David Alabaster, Pavements Engineer, Transit New Zealand who co-wrote a paper titled *New Zealand's Performance Specifications for Design and Construction of Unbound Granular Pavements*. This paper is published in this issue of the REAAA Journal.

The New Zealand is now accepting submissions for the 2004 REAAA NZ Chapter Technical Paper Competition. The closing date for the submission of papers is 30 September 2004. Papers can be submitted by mail or email to: The Secretary, REAAA New Zealand Chapter, PO Box 12 647, Wellington New Zealand (tel: +64-4-5298186; fax: +64-4-5298187; e-mail: lisapallister@reaaa.co.nz).

Evaluation of Stainless Steel Reinforcement for Use in Concrete Bridge Structures to Prevent Corrosion Damage in New And Existing Structures

Corrosion of reinforcement steel (mild steel) is a major problem for concrete bridges exposed to aggressive environments such as seawater or saline ground water. The corrosion is greatly exacerbated by the penetration of chloride ions in the seawater to the steel bars in concrete. Many millions of dollars are spent Australia wide to repair damage caused to bridge structures by corrosion of reinforcing steel and the consequent spalling of concrete. Advanced corrosion may seriously reduce the load capacity of bridge structures and their service life.

Damage to affected structures is rectified through patch repair, which is often unsuccessful in the long run, or through an expensive electrochemical process called cathodic protection, which must be maintained throughout the remaining life of the structure.

Incorporation of appropriate grades of stainless steel reinforcing bars in sensitive parts of a new bridge structure (e.g. tidal and splash zones which are most prone to corrosion damage) or replacement of damaged bars with new stainless steel bars in an existing structure, provide an alternative approach for effective management of bridge structures and low life cycle cost. However, published literature states that coupling stainless steel with mild steel in concrete, particularly when subjected to seawater ingress, could enhance the corrosion of the latter by setting up a galvanic corrosion cell. ARRB recently conducted research to find out whether this is a practical risk, and if so, the conditions under which the corrosion problem would be enhanced. Work conducted to date has shown that, even at high level of chloride contamination, stainless steel can be used to replace corroded mild steel and prevent future damage to the structure. Significant savings can be achieved in maintenance cost through the application of the outcomes of this research.

Contact: Dr Ahmad Shayan, Chief Scientist, ARRB (ahmads@arrb.com.au)

How Will New Heavy Vehicles Impact on Pavement Performance?

During 2002/03 ARRB undertook a project titled "Impact of New Heavy Vehicles on Pavement Wear and Surfacings" for Austroads. The project aimed to build our knowledge of the effects of increased axle loads on road deterioration. Such knowledge is very relevant to the issue of allowing for improved road transport efficiency while protecting the road pavement asset.

The research focussed on the relative effects of increased axle loads on pavement wear for unbound granular pavements with thin bituminous surfacings. The project involved full scale accelerated load testing, laboratory materials characterisation and associated analysis and reporting. The ARRB Accelerated Loading Facility (ALF) was used for the full scale load testing.

A key issue identified in the project was the relationship between the material properties of the unbound granular materials tested and their field performance. This was particularly highlighted for a lower-quality material which performed poorly having high variability compared to the higher-quality materials. The performance of these low-quality materials provided an insight into the effects of increased axle loading on a fragile, lower-standard road network. In contrast, the rates of deformation and distress for the higher-quality materials were much lower and more uniform.

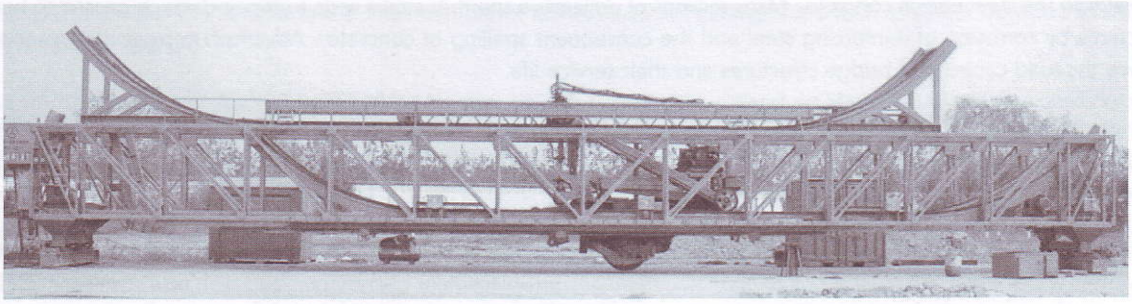
Load-damage exponents are used to assess the "exponential" effect of different axle loads on the traffic life of road pavements. Load-damage exponents found for rutting in granular pavements were between 2 and 5. The repeated load triaxial (RLT) laboratory test correctly ranked the pavement material performance compared to the accelerated loading. Another interesting observation was the apparent inability of the structural number (SNP) to describe the performance of the different test pavements. This has implications for the use of this parameter in network level pavement deterioration models. However, SNP was found to be an appropriate indicator of performance within a given test pavement.

Although the project produced significant findings for three different pavement materials, the research was limited. The accelerated pavement tests were conducted with single axle loads on dual tyres, at one moisture condition and with minimal horizontal or tractive forces. Heavy vehicle effects under different circumstances, or for a wider range of pavement conditions, were not included. However, the benefits of the performance data gathered are clear as the research has moved our understanding into the effects of increased axle loads on thin surfaced granular pavements forward. The data generated will be used to improve existing performance prediction models.

It was concluded that further research was required to investigate effects such as horizontal and tractive forces applied by heavy vehicles, the effects of tyre type and pressure, and the performance of different pavement types such as those containing cemented materials. Research on the impact of heavy vehicles on the infrastructure is continuing at ARRB through Austroads national strategic research initiative program.

Footnote: The Australian Accelerated Loading Facility (ALF) achieved a significant milestone in 2004 as it reached its 20th anniversary of operation. As typified above, the ALF has successfully demonstrated its ability as an instrumental research tool to improve our knowledge of the performance of pavements under a variety of conditions. ALF technology is international: three ALFs operate in the US and one in China.

Contact: Richard Yeo, Principal Engineer, ARRB (richardy@arrb.com.au)



The Accelerated Loading Facility in Beijing, China

Development of Cementitious Binders Incorporating Fly Ash and Blended Slag Cement

Cementitious binders are used for formulation of concrete mixes and stabilisation of road pavements. Recent trends in the concrete industry have involved the incorporation of ingredients other than Portland cement for achieving two objectives related to environmental issues as well as the main concrete technology related issue, being improvement of the performance properties of the concrete. The environmental objectives include:

- ❏ reducing the stockpile of waste material by finding useful applications for them in the concrete, which would also preserve natural resources; and
- ❏ reducing CO_2 emission by replacing a proportion of the cement by the waste material in the concrete formulation.

Blast furnace slag is an industrial by-product which is already used for producing blended cement. Fly ash derived from burning brown coal has chemical ingredients that could potentially be harmful in some concrete mixes. By balancing the ingredients, binder formulations can be produced for concrete as well as stabilisation purposes.

Recently ARRB conducted sponsored research on these materials and the results have shown that up to 30% of the blended cement can be replaced by the fly ash without detrimental effects. Similarly, the fly ash could be incorporated in stabilisation binders for road pavements for both slow-setting and rapid setting applications. The outcomes of this research will benefit both the producers of materials and the environment as a whole.

Contact: Dr Ahmad Shayan, Chief Scientist, ARRB (ahmads@arrb.com.au)

15th International Road Federation World Meeting 2005

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Supporting organisations: Roads Association of Thailand; The Ministry of Transport, Thailand